THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. XII.—DECEMBER, 1902.

ORIGINAL ARTICLES.

I.—The Canadian Rockies. Part I: On a Collection of Middle Cambrian Fossils obtained by Edward Whymper, Esq., F.R.G.S., from Mount Stephen, British Columbia.[1]

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE XXII.)

(*Continued from the November Number, p.* 505.)

THE accompanying section (Plate XXII) will serve to show, *diagrammatically* (after Dr. Ami), the succession of the Cambrian rocks at Mount Stephen and Mount Field, B.C., and the position of the Trilobite bed on the flanks of Mount Stephen (referred to on p. 503) from which Mr. Whymper's collection was obtained.

Mr. C. D. Walcott, in his paper on the Cambrian fauna of Mount Stephen (Amer. Journ. Sci. [3], 1888, vol. xxxvi, pp. 161*–166), writes: "Of the nine or more species found at Mount Stephen, six are stratigraphically located in the Cambrian system. Two species—*Ogygia* ?? *Klotzi* and *Ptychoparia Cordilleræ*—are unknown from any other locality.

"The next fauna above the *Olenoides* beds of the Highland section is of Upper Cambrian or Potsdam age, and contains three undetermined species of *Hyolithes*; *Dicellocephalus Pepinensis*, *D.* (type of *D. Minnesotensis*), *Dicellocephalus* sp.; *Ptychoparia* (*Euloma* ?) *dissimilis*, *Ptychoparia* sp. ?; *Arethusina Americana*; *Illænurus* sp. ? Of this fauna two species are identical with those from the higher Potsdam fauna at Eureka, viz. *Ptychoparia* (*E.* ?) *dissimilis* and *Arethusina* ? *Americana*; whilst *Belleroparia antiquata* and *Dicellocephalus Pepinensis* occur in the Upper Potsdam sandstone of Wisconsin. The presence of the *Pleurotomaria*-like shells and the species just mentioned correlates the fauna of Mount Stephen with that of the upper horizon of the Potsdam faunas of Wisconsin and Nevada.

[1] Read before the British Association for the Advancement of Science (Section C, Geology), Belfast, September 11th, 1902.

"From the data mentioned I am led to conclude that the Mount Stephen fauna described by Dr. Rominger should be referred to about the horizon of the upper portion of the Middle Cambrian fauna. This correlation, united with the discovery of the *Olenellus*-fauna by Dr. George M. Dawson, in 1885, near Kicking-Horse-Pass, on the line of the Canadian Pacific Railway, leads me to think that the Middle Cambrian fauna will be found to extend all along the western side of the great Keweenawan continental area, from Southern Nevada far into British America, and that this area will be found to belong to one geologic and faunal province of the Cambrian system.

"Dr. Rominger describes the new genus *Embolimus* and five new species of Trilobites, viz., *Ogygia Klotzi*, *O. serrata*, *Embolimus spinosa*, *E. rotundata*, and *Conocephalites Cordillerœ*. He also identifies *Monocephalus Salteri* ? Billings, *Bathyurus* ? *Agnostus* (compare *A. integer*, Barr.), and the genera *Orthis*, *Obolella*, *Kutorgina*, *Leptæna*? *Metoptoma*, and *Hyolithes*."

Ogygopsis Klotzi, Rom., sp., 1887.

Ogygia Klotzi, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 12, pl. i, fig. 1.
Ogygia Klotzi, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 166.
Ogygopsis Klotzi, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 446.
Ogygia [*Ogygopsis*] *Klotzi*, Roem., G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 58.

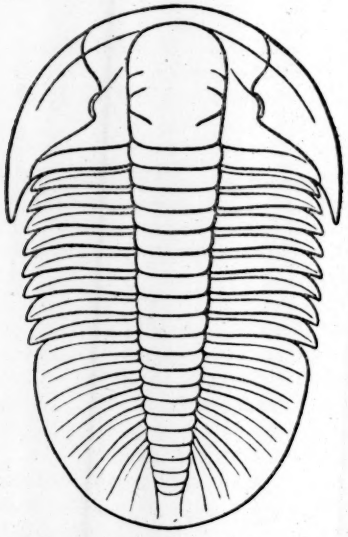


Fig. 1.—*Ogygopsis Klotzi*, Rom., sp., 1887.
Middle Cambrian: Mount Stephen, B.C. Two-thirds nat. size.

This Trilobite is one of the most abundant of the species obtained from the Middle Cambrian of Mount Stephen, B.C. In Mr. Whymper's collection there are twenty-eight nearly complete examples and

twelve pygidia. There are also fourteen examples of *O. Klotzi*, junior, showing the younger stages of this well-preserved species.

Rominger states that this species attains a length of 11 centimetres and a breadth of 6 centimetres, and that specimens graduate down to as small as 16 millimetres in length. Of the fine series brought home by Mr. Whymper, only two or three examples have the free cheeks attached to the head. This suture-line, separating the free cheek from the fixed cheek and glabella, was evidently a weak line of union in the hard head-shield of most Trilobites, save in forms like *Illænus*, *Homalonotus*, etc., in which it is generally more firmly united to the head.

One is at first struck by the remarkable family likeness between *O. Klotzi* and *O. Buchi* from our own Llandeilo Flags, but after a more careful comparison one observes many important points by which to distinguish them from one another. In *O. Klotzi* the difference between the length and breadth is as 11 cm. to 6 cm., whilst in *O. Buchi* the length is $12\frac{1}{2}$ cm. to $10\frac{1}{2}$ cm. in breadth. Both the Mount Stephen and the Builth specimens, as is usually the case with fossils preserved in a slate rock, have undergone considerable compression.

The comparative length of the head, thorax, and pygidium is 3, 3, and 4 cm. respectively, the tail being the longest division of the body. The axis of the body, which is 18 mm. wide at the neck-furrow, diminishes very gradually to 10 mm. and less near the distal extremity, but is not visibly constricted as in *O. Buchi*, in which the axis rapidly diminishes from 15 to 5 mm. in the pygidium (see Salter's figures).

The glabella is nearly straight-sided and not expanded in front, as is usually the case in *Ogygia* proper. There are three lateral furrows in the glabella, which is rounded in front and separated from the anterior border by a fairly broad rim. There is a well-defined ocular ridge, and the palpebral lobe is narrow. The neck-furrow is smooth, and about 4 mm. deep by 18 mm. broad.

The fixed cheeks are narrowest at the orbits and expand broadly in front of the eyes, with a compressed semicircular outline around the glabella, and are half as wide as the glabella itself, only contracting slightly before uniting with the latero-anterior margin. Behind the orbits the fixed cheeks again expand outwardly at an acute angle, until they reach the ends of the neck-segment. The free cheeks are axe-shaped (the outer cheek border representing the rounded cutting-edge of the axe-blade). The latero-posterior angle of the crescent-like free cheek is produced backwards as a short stout spine which reaches to the third free thoracic segment.

Thoracic segments eight in number, but little curved, axial portion without ornament of ridges or tubercles, pleural portion about one-third longer than width of axis; pleural groove distinct, pleuræ slightly curved and pointed at their extremities, and very uniform in size; pygidium deep, but less broad than in *O. Buchi*; ribs of tail reaching nearly to the border, with no very distinct smooth or striated margin as in *O. Buchi*, only a narrow convex rim against

"From the data mentioned I am led to conclude that the Mount Stephen fauna described by Dr. Rominger should be referred to about the horizon of the upper portion of the Middle Cambrian fauna. This correlation, united with the discovery of the *Olenellus*-fauna by Dr. George M. Dawson, in 1885, near Kicking-Horse-Pass, on the line of the Canadian Pacific Railway, leads me to think that the Middle Cambrian fauna will be found to extend all along the western side of the great Keweenawan continental area, from Southern Nevada far into British America, and that this area will be found to belong to one geologic and faunal province of the Cambrian system.

"Dr. Rominger describes the new genus *Embolimus* and five new species of Trilobites, viz., *Ogygia Klotzi*, *O. serrata*, *Embolimus spinosa*, *E. rotundata*, and *Conocephalites Cordillerœ*. He also identifies *Monocephalus Salteri* ? Billings, *Bathyurus* ? *Agnostus* (compare *A. integer*, Barr.), and the genera *Orthis*, *Obolella*, *Kutorgina*, *Leptæna*? *Metoptoma*, and *Hyolithes*."

Ogygopsis Klotzi, Rom., sp., 1887.

Ogygia Klotzi, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 12, pl. i, fig. 1.
Ogygia Klotzi, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 166.
Ogygopsis Klotzi, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 446.
Ogygia [*Ogygopsis*] *Klotzi*, Roem., G. F. Matthew,-1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 58.

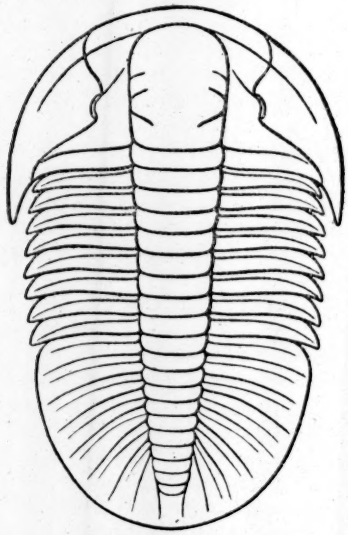


Fig. 1.—*Ogygopsis Klotzi*, Rom., sp., 1887.
Middle Cambrian: Mount Stephen, B.C. Two-thirds nat. size.

This Trilobite is one of the most abundant of the species obtained from the Middle Cambrian of Mount Stephen, B.C. In Mr. Whymper's collection there are twenty-eight nearly complete examples and

twelve pygidia. There are also fourteen examples of *O. Klotzi*, junior, showing the younger stages of this well-preserved species.

Rominger states that this species attains a length of 11 centimetres and a breadth of 6 centimetres, and that specimens graduate down to as small as 16 millimetres in length. Of the fine series brought home by Mr. Whymper, only two or three examples have the free cheeks attached to the head. This suture-line, separating the free cheek from the fixed cheek and glabella, was evidently a weak line of union in the hard head-shield of most Trilobites, save in forms like *Illænus*, *Homalonotus*, etc., in which it is generally more firmly united to the head.

One is at first struck by the remarkable family likeness between *O. Klotzi* and *O. Buchi* from our own Llandeilo Flags, but after a more careful comparison one observes many important points by which to distinguish them from one another. In *O. Klotzi* the difference between the length and breadth is as 11 cm. to 6 cm., whilst in *O. Buchi* the length is $12\frac{1}{2}$ cm. to $10\frac{1}{2}$ cm. in breadth. Both the Mount Stephen and the Builth specimens, as is usually the case with fossils preserved in a slate rock, have undergone considerable compression.

The comparative length of the head, thorax, and pygidium is 3, 3, and 4 cm. respectively, the tail being the longest division of the body. The axis of the body, which is 18 mm. wide at the neck-furrow, diminishes very gradually to 10 mm. and less near the distal extremity, but is not visibly constricted as in *O. Buchi*, in which the axis rapidly diminishes from 15 to 5 mm. in the pygidium (see Salter's figures).

The glabella is nearly straight-sided and not expanded in front, as is usually the case in *Ogygia* proper. There are three lateral furrows in the glabella, which is rounded in front and separated from the anterior border by a fairly broad rim. There is a well-defined ocular ridge, and the palpebral lobe is narrow. The neck-furrow is smooth, and about 4 mm. deep by 18 mm. broad.

The fixed cheeks are narrowest at the orbits and expand broadly in front of the eyes, with a compressed semicircular outline around the glabella, and are half as wide as the glabella itself, only contracting slightly before uniting with the latero-anterior margin. Behind the orbits the fixed cheeks again expand outwardly at an acute angle, until they reach the ends of the neck-segment. The free cheeks are axe-shaped (the outer cheek border representing the rounded cutting-edge of the axe-blade). The latero-posterior angle of the crescent-like free cheek is produced backwards as a short stout spine which reaches to the third free thoracic segment.

Thoracic segments eight in number, but little curved, axial portion without ornament of ridges or tubercles, pleural portion about one-third longer than width of axis; pleural groove distinct, pleuræ slightly curved and pointed at their extremities, and very uniform in size; pygidium deep, but less broad than in *O. Buchi*; ribs of tail reaching nearly to the border, with no very distinct smooth or striated margin as in *O. Buchi*, only a narrow convex rim against

which the coalesced pleuræ abut. There are about eleven well-marked coalesced segments in the pygidium, and their backward curvature is much greater than that of the free thoracic segments, gradually increasing more and more towards the extremity of the tail, where they meet the axis at a very acute angle indeed.

When comparing *O. Klotzi* with our English forms of *Ogygia* one is led to the conclusion that the earlier forms such as *O. Selwyni*, Salter, and *O. peltata*, are probably nearer the species from Mount Stephen than is *O. Buchi*; but that is not the opinion of Mr. Walcott. In any case *O. Klotzi* must be considered as a remarkably specialized form, to be met with in such early rocks as the Middle Cambrian of Mount Stephen, and has led Dr. G. F. Matthew to suggest that this bed may be really of Upper Cambrian age.

Walcott says of this Trilobite: "This is a fine large species, and distinct from any known to me from the Cambrian terrane. It is more a type of the second fauna than of the first; and its reference to the genus *Ogygia* is in accord with its general characters. It differs, however, in the important feature of having an ocular ridge extending from the anterior margin of the eye to the dorsal furrow beside the glabella. The palpebral lobe is also more narrow and elongate than the eye of most species referred to *Ogygia*. All other parts of the head, thorax, and pygidium relate it more closely to *Ogygia* than to any other genus. The oldest known species of the genus, *O. Selwyni*, Salter, from the Arenig terrane of Wales, is not quite so closely related in form to *O.? Klotzi* as to the *O. Buchi* from the Llandeilo terrane."

"It is remarkable that a genus showing so little variation from *Ogygia* proper should occur at an horizon so much lower, in an area separated by over 5,000 miles from that in which the genus flourished at a later period in geologic history."

Having regard to the fact that *Ogygopsis Klotzi* differs from *Ogygia* proper in having a well-defined ocular ridge and a narrow palpebral lobe, it seems convenient to separate this Rocky Mountain form generically from the other examples of *Ogygia* as represented by *O. Buchi*, more especially as the latter occurs in beds so much younger than the Middle Cambrian, in which *O. Klotzi* is found (see C. D. Walcott, Proc. U.S. National Museum, 1888, vol. xi, p. 446).

Bathyuriscus Howelli, Walcott, 1886.

Bathyuriscus Howelli, Walcott, 1886: Bull. U.S. Geol. Surv., No. 30, p. 216, pl. xxx, figs. 2, 2*a*.
Embolimus rotundata, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 16, pl. i.
Embolimus rotundatus (Rom.), Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 165; referred to *B. Howelli*.

There are six nearly complete examples of this species (three showing the free cheeks *in situ*, more or less perfectly) and one detached pygidium, all from Mount Stephen, in Mr. Whymper's collection. The figure represents the species one-fourth larger than natural size.

This species might, at first sight, be confounded with junior specimens of *O. Klotzi*, but on closer examination it will be found

that there are some important differences. The total length of a specimen of *B. Howelli* is 40 mm.; the head is 13 mm. in length by 25 mm. in breadth, the thorax 17 mm. in length by 23 mm. in breadth, and the pygidium 10 mm. in length by 20 mm. in breadth. The glabella in *B. Howelli* is broader in front (not straight-sided as in *O. Klotzi*), and has four glabellar furrows on each side (not three pairs as in *O. Klotzi*).

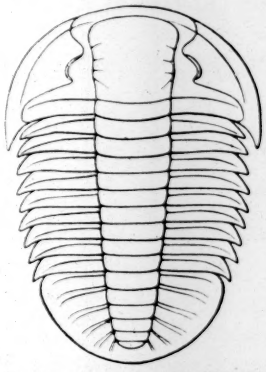


Fig. 2.—*Bathyuriscus Howelli*, Walcott, 1886.
Middle Cambrian: Mount Stephen, B.C. One-fourth larger than nat. size.

The head-shield is very short in proportion to its breadth; the fixed cheeks are narrow, the anterior angle of the eye nearly touching the glabella at its fourth furrow, but expanding again in front, where it surrounds the glabella and forms a rather broad and slightly raised margin to the shield. The ocular border is directed more forward than in *O. Klotzi*, and the latero-posterior margin of the fixed cheek, where it unites with the neck-furrow, is rounded, not acute as in *O. Klotzi*. The neck-furrow and its pleuræ are broad and smooth, and do not carry any tubercles. The free cheeks are rather narrow, and produced backwards into a short and broad spine reaching to the second segment of the thorax. The axis of the body is 8 mm. broad in front and tapers to 5 mm., where the thorax unites with the pygidium, and is 4 mm. broad at the distal end of the pygidium.

There are *nine*[1] thoracic segments in *B. Howelli* and eight in *O. Klotzi*. There are six coalesced segments in the pygidium of this species and eleven in *O. Klotzi*. There are no spines or tubercles on the axis, and the pleuræ of the thoracic segments are straight and moderately pointed backward at their extremities.

Several other species of this genus, which extends from the Middle to the Upper Cambrian (and which was first proposed by Meek in

[1] In Bull. U.S. Geol. Surv., 1886, No. 30, p. 216, Walcott gives the number of thoracic rings as eight; but in Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 165, he correctly gives the number as *nine*, stating that in the type one segment had been forced beneath the head, a fact that was overlooked in the original specimen. A comparison of specimens from Mount Stephen with the type from Pioche, Nevada, shows them to be specifically identical.

1873) have been described, viz., *B. Haydeni*, *B. parabola*, *B. productus*; the last-named may possibly be identical with *B. Howelli*, described here.

Dr. G. F. Matthew has added another species from Mount Stephen, B.C., *Bathyuriscus pupa*, Matthew (1899), Trans. Roy. Soc. Canada, vol. v, p. 51, pl. ii, fig. 5.

Bathyuriscus (Kootenia) Dawsoni, Walcott.

Bathyuriscus (*Kootenia*) *Dawsoni*, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 446. Middle Cambrian: Mount Stephen.

Bathyuriscus (*Dorypyge*) *Dawsoni* (Walcott), Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 56, pl. iii, fig. 1.

M. Cambrian: Mount Stephen. (Not in Whymper Collection.)

Bathyuriscus pupa, G. F. Matthew, 1899.

Bathyuriscus pupa, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 51, pl. ii, fig. 5.

M. Cambrian: Mount Stephen. (Not in Whymper Collection.)

Neolenus serratus, Rominger, sp., 1887.

? *Olenoides Nevadensis*, Meek, 1877: U.S. Geol. Expl. 40th Par., Palæontology, vol. iv, p. 25.

? *Olenoides Nevadensis*, Walcott, 1886: Bull. U.S. Geol. Surv., No. 30, p. 181, pl. xxv, fig. 7.

Ogygia serrata, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 13, pl. i, figs. 2, 2*a*.

Olenoides Nevadensis, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 443.

Olenoides Nevadensis, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 165.

Neolenus serratus (Roem., sp.), G. F. Matthew, 1899: Trans. Roy. Soc. Canada, pp. 52–54.

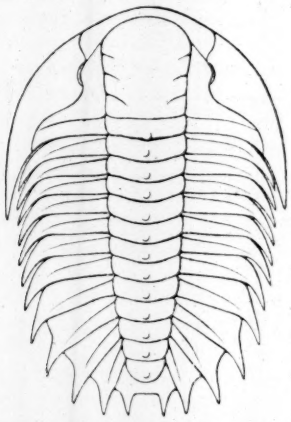


Fig. 3.—*Neolenus serratus*, Rominger, sp., 1887.
Middle Cambrian: Mount Stephen, B.C. Drawn rather less than nat. size.

In Mr. Whymper's collection there are two nearly complete examples and several pygidia of this well-marked species, with which it is probable *N. granulatus*, Matthew,[1] may also be associated,

[1] G. F. Matthew, "Studies on Cambrian Faunas": Trans. Roy. Soc. Canada, 1899, p. 55, pl. ii, figs. 1*a–c*.

but of this species I have not seen the original specimen, only the figure. Dr. G. F. Matthew (op. cit.) is probably justified in separating this form from *Olenoides*, but it is very difficult to decide whether the imperfect specimen figured and described by Walcott as the *Olenoides Nevadensis* of Meek is identical with Rominger's *O. serrata*.

Length of largest entire specimen in Mr. Whymper's collection 6 cm., breadth 4 cm. (Dr. Rominger gives the size of his specimen as 7 c. long and 5 c. wide.) The head is 21 mm. long, the seven free and movable thoracic somites also 21 mm. long, and the pygidium 17 mm. long; the glabella is 13 mm. broad at the cervical furrow, and increases 15 mm. in breadth in front. Three lateral furrows divide the glabella into four lobes on each side; the fixed cheeks form a frontal border separating the glabella from the margin of the head-shield, which is slightly raised; they (the fixed cheeks) are broader near the front of the head, and contract slightly in front of the eyes, when they expand again to form the ocular lobes; then, after a slight contraction, they expand to form an acute angle laterally in uniting with the pleuræ of the cervical ring. The free cheeks are somewhat narrow, and produced to form the lateral spines of the head-shield, which extend backwards to the fourth segment; the eyes are small and narrow, and unite with the glabella by a distinct ocular ridge at their front angles. The axis of the neck-furrow is as broad as one of its pleuræ; the seven free thoracic rings have a strongly marked axis, which gradually diminishes from 13 mm. behind the neck-lobe to 9 mm. in front of the pygidium; the pleuræ are as wide as the axis, broad and flat, with a strongly marked pleural groove, and at the fulcral point, which is clearly marked, their extremities are bent sharply back, and are produced into spines which overlap one another and become slightly broader posteriorly; the five coalesced somites of the pygidium are much expanded and end in strong marginal spines. There is a central tubercle (or, according to Rominger, a short spine) upon the axis of each somite and five upon the pygidium. The hypostome (figured by Rominger) is rounded shield shape (see op. cit., pl. i, figs. 2*b*, *c*).

"The species," says Dr. G. F. Matthew, "included in the new genus (*Neolenus*) are closely related to *Parabolina* (Salter, 1849); they differ chiefly in having a longer pygidium and shorter thorax; also the eye-lobes are placed further back and the marginal fold is wider."

After a comparison of Dr. Matthew's figures of *Parabolina* (in Fauna of St. John's Group, Trans. Roy. Soc. Canada, 1891, vol. ix, p. 51, pl. xiii, fig. 5) I am led to the conclusion that the St. John's specimens are too fragmentary for comparison with our Mount Stephen examples, and do not assist in arriving at such a conclusion. Nor can the present species be placed, as Dr. Rominger believed, near to *Ogygia Klotzi*, save as one of an already well-differentiated group of genera and species of Cambrian Trilobites.

Neolenus granulatus, Matthew, 1899.

Neolenus granulatus, G. F. Matthew, 1899: Trans. Roy. Soc. Canada [2], vol. v, p. 55, pl. ii, figs. 1*a–c*.

(Very near to, if not identical with *N. serratus*.) M. Cambrian: Mount Stephen.

Ptychoparia Cordilleræ, Walcott, 1888.

Conocephalites Cordilleræ, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 17, pl. i, fig. 7.
Ptychoparia Cordilleræ, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 165.
Ptychoparia Cordilleræ, G. F. Matthew, 1899: Trans. Roy. Soc. Canada, sect. iv, pp. 44, 45, pl. i, fig. 7.

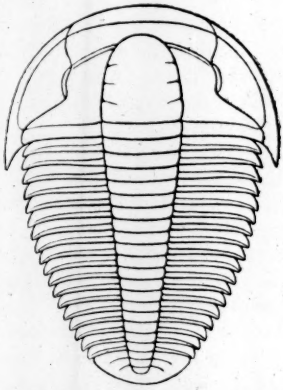


Fig. 4.—*Ptychoparia Cordilleræ*, Rom., sp., 1887.
Middle Cambrian: Mount Stephen and Ball's Valley, B.C. Enlarged 3 times nat. size.

Mr. Whymper's collection affords twelve specimens of this little Trilobite, seven of which are from Ball's Valley and five from Mount Stephen, B.C. Walcott states that he has seen a specimen of this species (*Ptychoparia Cordilleræ*) from Mount Stephen, 23 mm. in length, which had nineteen thoracic segments, agreeing in this respect with *Ptychoparia Piochensis* of Walcott, from the same horizon at Pioche, Nevada. The head is, however, unlike the other species, being more closely related to *P. Kingi* of Meek. (Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 165.)

G. F. Matthews says: "There appears to be some variation in the number of joints in the thorax; Dr. Rominger enumerates from 14 to 17, but the lower numbers were probably mutilated individuals. . . . . The author has found 18 as a constant number in examples 16 mm. in length and upwards to the adult." The relative number of segments and the length in *Ptychoparia Cordilleræ* are thus shown:—(Walcott), one specimen, 23 mm. long, with 19 thoracic segments; (Matthew), several specimens, 16 mm. long and upwards to adult, 18 thoracic segments (constant); (Rominger), several specimens, 25 mm. average length, 17 thoracic segments,

but in two specimens one had 14 segments and one 15 thoracic segments. Of eleven specimens in the Whymper Collection three had 12 segments, four had 13, one had 14, one had 15; and two had 18 thoracic segments. I think the number of segments must therefore be considered inconstant, or that an examination of a larger number of specimens may prove the existence of a second species broader and shorter than *Ptychoparia Cordilleræ*.

The glabella is tumid, but rather narrower and rounded in front, with three marginal furrows; the fixed cheeks surround it in front, the border being bent upwards and forming a strong raised rim; fixed cheeks are very broad in front; eye-lobe short, distant from the glabella, but united to it by a well-marked ocular ridge; free cheeks narrow, with bluntly pointed lateral spines which extend backwards only to the second free thoracic segment; axis equal to one-third the breadth of body-segments in front, but tapering gradually from 4 mm. at the neck-furrow to 1 mm. at the pygidium; pleuræ parallel, but little curved, fulcral groove deep, margins of pleuræ raised; pygidium very small, consisting of three coalesced segments; the axis extends nearly to the extremity; two pairs of lateral furrows faintly mark the pleuræ in the shield.

I have not been able to detect the granulated ornamentation observed by Dr. Matthew in this Trilobite, nor the row of low tubercles on the median line of the thorax. Whether the ornament can be seen or not depends so much upon the fineness or roughness of the matrix in which these small fossils are preserved.

Dr. Matthew observes that among the Trilobites of the fauna of Mount Stephen *Ptychoparia* is the only one which has a specially Lower Cambrian aspect. The genus is now a very extensive one, and has absorbed a great number of species formerly referred to *Conocephalites*, but certainly the whole of the latter genus does not belong to *Ptychoparia*.

Zacanthoides (Olenoides) spinosus, Walcott, 1886.

Olenoides spinosus, Walcott, 1886: Bull. U.S. Geol. Surv., No. 30, p. 184, pl. xxv, figs. 6, 6*a*.
Embolimus, Westwood, 1883: Phil. Mag., ii; a genus of Hymenoptera.
(*Embolimus*) *spinosa*, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 15, pl. i, fig. 3.
Zacanthoides spinosus, Walcott, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 57.
Zacanthoides spinosus, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, pp. 164–5.

Only one poorly preserved example (impression and counterpart) of this interesting form has been brought home by Mr. Whymper; but by the great kindness of Drs. Whiteaves and Ami I have been allowed to see four excellent specimens, one with a fine head, selected from the collection of the Geological Survey of Canada, in Ottawa, made by Dr. Ami and others from Mount Stephen.

The specimen is 55 mm. long and 35 mm. broad across the head; length of head, 17 mm.; length of thorax, 23 mm.; length of pygidium, 15 mm.

The glabella is large, moderately convex, sides nearly straight, very slightly expanded in front, reaching close to the anterior margin of the cephalic shield, which forms a narrow raised rim. There are four well-marked glabellar furrows, the hinder pair being the largest, and running obliquely backwards, the third and fourth pairs curve forwards towards the front of the glabella.

The axis of the cervical (or occipital) ring is slightly indented on each side on its anterior margin, and there is the raised base of a central spine, directed backwards, as in other Onellidæ, although the spine itself is wanting. The side-lobes or pleuræ of the cervical ring are short and arched, and terminate laterally in a small stout spine directed outwards and backwards, and lying well within the great lateral spines of the free cheek. The fixed cheek has a wide, semicircular expansion on each side of the glabella above the eye, reaching from the cervical furrow behind to the fourth furrow on the glabella in front, the eye itself making a long narrow raised border to the fixed cheek. The facial suture nearly touches the glabella in front, and then bends slightly outwards in a curved line until it reaches the anterior margin of the head-shield.

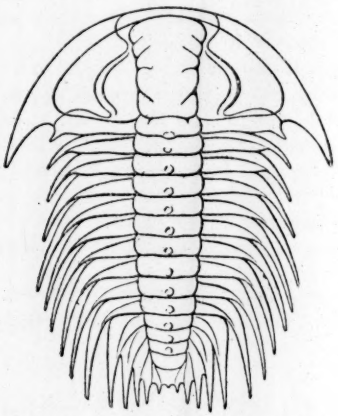


Fig. 5.—*Zacanthoides* (*Olenoides*) *spinosus*, Walcott, 1886.

The head (in *Zacanthoides*) forms the broadest portion of the Trilobite, the spines of the free cheeks being directed very much outwards as well as backwards, and measuring 42 mm. across. Their points do not reach further back than the second free somite. There are nine free thoracic somites, the extremities of which form long, sharply recurved spines, overlapping each other and increasing in length from the head to the pygidium, the hindmost being more than twice as long as the pleura itself; the pleuræ diminishing rapidly in breadth from before backwards as their spines increase in length.

The pygidium has four distinct coalesced annuli with a terminal plate fringed by three small spines. The spines of the four

abdominal or pygal segments correspond with those of the pleuræ, but they diminish very rapidly to the extremity of the tail. The axis of all the free thoracic segments and perhaps the first of the coalesced caudal segments appear to have each supported a central spine, as in *Zacanthoides typicalis*, *Olenellus* (*Holmia*) *Kjerulfi*, Holm, *O. Gilberti*, Walcott, *Olenellus Callavei*,[1] *O.* (*Holmia*) *Bröggeri*, and many other Cambrian forms of Trilobites.

If one is surprised to find a genus such as *Ogygia Buchi* in the Llandeilo Flags of Builth represented in the still earlier Middle Cambrian fauna by *O. Klotzi* at Mount Stephen, B.C., it is equally remarkable to find *Zacanthoides spinosus* at Mount Stephen, B.C., and *Z.* (*O.*) *typicalis* (in Middle Cambrian), Pioche, Nevada, U.S.A., so closely resembling and preceded by such a form as *Olenellus* (*Holmia*) *Kjerulfi* in the Lower Cambrian of Norway,[2] which, although belonging to another genus, was clearly an ancestral form.

Concerning the genus *Embolimus* Mr. Walcott writes[3]:—"The generic name *Embolimus* was given by Westwood to a genus of Hymenoptera in 1833. It was spelt *Embolemus* by Westwood, and was corrected by Professor Agassiz to *Embolimus* in his Nomenclator Zoologicus.

"The first species named under this genus by Dr. Rominger, *Embolimus spinosa*, was described as *Olenoides spinosus* in 1886, and the second species, *Embolimus rotundatus*, as *Bathyuriscus Howelli*.

"When studying the Georgina fauna in 1885, I found that the genus *Olenoides* was probably the same as the genus *Dorypyge* of Dames. Wishing more material for comparison I left all the species under the genus *Olenoides*. A large, fine species of the genus *Olenoides* was collected in the Cambrian shales of Northern Alabama in 1886, which proved conclusively that *Dorypyge* was founded on a species congeneric with the type of *Olenoides*. I then recognized that the species *Olenoides typicalis*, *O. spinosus*, *O. levis*, and *O. flagricaudatus* formed a distinct generic group, which I was preparing to illustrate when Dr. Rominger's paper appeared. As the generic name proposed by him is preoccupied I suggest the name *Zacanthoides*, including in it *Z. typicalis*, *Z. spinosus*, *Z. levis*, and *Z. flagricaudatus*. The species remaining under *Olenoides* are *O. Nevadensis*, *O. Marconi*, *O. quadriceps*, and *O. Wasatchensis*. After comparing specimens I found that *Embolimus spinosa*, Rom., = *Zacanthoides spinosus*, Walcott; *Embolimus rotundata*, Rom., = *Bathyuriscus Howelli*, Walcott; *Ogygia serrata* = *Olenoides Nevadensis*, Meek; and that the last two, *Conocephalites Cordilleræ*, Rom., = *Ptychoparia Cordilleræ*, Rom. (sp.), and *Ogygia*?? *Klotzi*, Rom., are new additions to the previously known Cambrian fauna."

[1] *Olenellus Callavei*, Lapworth: Geological Magazine, 1891, pp. 529–536, Pls. XIV and XV.

[2] G. Holm, "On *Olenellus Kjerulfi*": Foren. Forhandl., 1887, Bd. ix.

[3] C. D. Walcott, "Cambrian Fossil from Mount Stephen, N.W. Territory of Canada": Amer. Journ. Sci. [3], 1888, vol. xxxvi, pp. 161*–166.

ORYCTOCEPHALUS, Walcott, 1886.

Bull. U.S. Geol. Surv., 1886, No. 30, p. 210.

1. Oryctocephalus Walkeri, G. F. Matthew, 1899.

Studies on Cambrian Faunas, No. 3: Trans. Roy. Soc. Canada, 1899, p. 60, pl. iii, fig. 2.

M. Cambrian: Mount Stephen, B.C. (Not in the Whymper Collection.)

2. Oryctocephalus Reynoldsi, F. R. Cowper Reed, 1899.

Geol. Mag., Dec. IV, Vol. VI, pp. 358–361.

M. Cambrian: Mount Stephen, B.C. (Not in the Whymper Collection.)

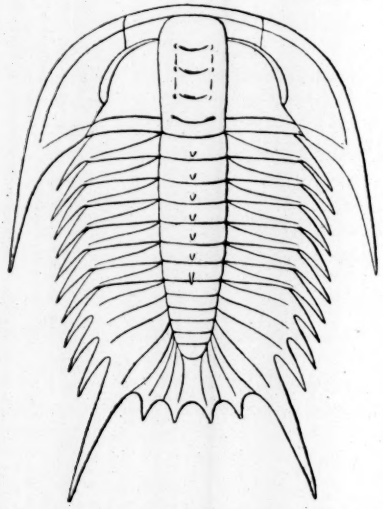


Fig. 6.—*Oryctocephalus Reynoldsi*, F. R. Cowper Reed, 1899.[1]
Middle Cambrian: Mount Stephen, B.C. (Original specimen in the Woodwardian Museum, Cambridge.)

This form has been fully described in this Magazine, Dec. IV, Vol. VI, 1899, pp. 358–361.

Conocephalites (Conaspis?) cf. perseus, Hall, 1862.

Conocephalites (*Conaspis*) *perseus*, Hall, 1862: Prelim. Rep. Fauna Potsdam Sandstone, Albany.

Conocephalites (*Conaspis?*) *perseus*, Hall, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 46, pl. ii, fig. 4.

(Glabella and fixed cheeks only.) M. Cambrian: Mount Stephen.

Corynexochus Roemingeri, Matthew, 1899.

Corynexochus Roemingeri, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 47, pl. ii, fig. 3.

(Glabella and fixed cheeks only.) M. Cambrian: Mount Stephen.

[1] Refigured here by permission of the author.

DOLICHOMETOPUS OCCIDENTALIS, Matthew, 1899.

Dolichometopus occidentalis, Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 49, pl. ii, fig. 2.

Only one example known (12 mm. long by 8 mm. wide).

Referred by Matthew to Angelin's genus *Dolichometopus*, of which only the head is known from Sweden.

(Unique.) M. Cambrian: Mount Stephen.

AGNOSTUS INTERSTRICTUS, White.

Probably there are several species of *Agnostus* from Mount Stephen. *A. interstrictus* is certainly found there.

"This species," says Walcott, "is very abundant at Antelope Spring, Utah, where it is associated with *Olenoides Nevadensis*, as at Mount Stephen." (Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 166.)

Whymper Collection.

AGNOSTUS MONTIS, Matthew, 1899.

Agnostus montis, Matthew: Trans. Roy. Soc. Canada, vol. v, p. 43, pl. i, fig. 6.
Agnostus cf. *integer*, Barr., 1887: Roeminger, Proc. Acad. Nat. Sci. Philad., pt. i, p. 18, pl. i, fig. 9.

M. Cambrian: Mount Stephen, B.C.

(Collected by Byron Walker, Esq., F.G.S.) Geol. Surv. Museum, Ottawa. Mr. Walcott writes[1] as follows:—

"*Hyolithellus micans*, Billings.—Black, shiny, concentrically striated or smooth, compressed tubes occur in the shale with the Trilobites, that appear to be identical with *H. micans* of the Middle Cambrian fauna of New York, Vermont, and Canada. These 'slender stems,' mentioned by Dr. Rominger, may be the same as the slender shells of this species which appear like compressed stems formed of shiny carbonaceous matter."

"It is doubtful what the specimen identified as *Monocephalus Salteri*? is. It may be the young of *Bathyuriscus Howelli*. The specimen figured as *Bathyurus*? is too badly defined to identify it. Of the remaining genera mentioned by Dr. Rominger I do not find any traces in the material before me with the exception of a fragment of *Orthis*."

"*Kutorgina Prospectensis*, Walcott?—A fragment of a species of *Kutorgina*, closely related to *K. Prospectensis*, occurs on the slate in association with *Ptychoparia Cordilleræ*. It is not improbable that it represents a new species."

Among the specimens obtained by Mr. Whymper from Ball's Valley, 23 miles distant from Field, may be mentioned *Ogygopsis Klotzi*, *Bathyuriscus Howelli*, *Ptychoparia Cordilleræ* (seven specimens), *Agnostus interstrictus*, *Stenotheca rugosa*, etc.

Dr. J. F. Whiteaves, F.G.S., Palæontologist to the Geological Survey of Canada, gives in *The Canadian Record of Science*, 1893, vol. v, pp. 205–8, a figure and description of a new genus and species of Phyllocarid Crustacean from the Middle Cambrian of Mount Stephen, B.C., of which Mr. Edward Whymper also secured four examples, one of which is figured here.

[1] Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 165.

Anomalocaris (gen. nov.).—"Carapace and its appendages unknown or too obscurely indicated for their characters to be defined; body many jointed and consisting of not less than nine to thirteen segments, exclusive of the caudal segment; ventral portion of each of the body-segments bearing a pair of slender, narrowly elongated and acutely pointed, simple and probably branchial appendages, of the nature of uropods, or foot-gills (?); posterior terminal segment margined with three pairs of caudal spines, one terminal and the other two lateral; the posterior pair of uropods represented in the woodcut apparently belonging to a pre-caudal segment whose posterior boundary has been obliterated.

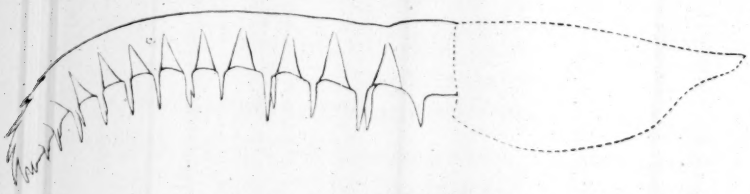


Fig. 7.—*Anomalocaris Canadensis*, Whiteaves (1892). Three-fourths nat. size (anterior part of carapace conjectural). Drawn by Miss G. M. Woodward from a specimen in very dark shale from the Middle Cambrian of Mount Stephen, obtained by Edward Whymper, Esq., F.R.G.S., in 1901.

"Body, inclusive of the tail, elongated, slender, decreasing slowly in size from the anterior to the posterior end, rather strongly curved posteriorly and nearly straight anteriorly, the length of the portion preserved varying in different specimens from nine to ten centimetres (as measured at from about the mid-height and following the curve of each), and the height or depth at the imperfect anterior end from twelve to seventeen millimetres, exclusive of the ventral appendages. Body or abdominal segments, which in all the specimens collected are abnormally flattened laterally, a little higher or deeper than long, broader above than below; the pair of ventral appendages are straight and prolonged downward at almost a right angle to the main axis of the body, for although there is a slight divergence in each pair, neither are directed distinctly backward nor forward. Between each pair of segments there is evidence of a wedge-shaped or very narrowly triangular lateral area or interval,[1] which is broadest or widest below and does not seem to extend quite to the dorsal margin. At the posterior end the segmentation is very obscurely defined. Caudal spines, which are simple, slender, longitudinally elongated, and acutely pointed, averaging 6 mm. in length by about 1 mm. in breadth at the base; the three pairs of spines about equal in length, though the two lateral ones are placed farther forward than the central and terminal pair. Surface markings entirely unknown.

"This genus and species are based upon upwards of fifty specimens

[1] This space appears to have been occupied by a membranous connection which united the harder tergal portion of each somite to its fellow; the integument, however, must have been very thin, probably like that of *Apus* and *Branchipus*.

collected from a band of shale of Middle Cambrian age at Mount Stephen, near Field Station on the Canadian Pacific Railway. Two of these specimens were collected by Mr. R. G. McConnell, of the Geological Survey of Canada, in 1888, and the remainder by Dr. H. M. Ami, of the same Survey, in 1891. The species seems to have been somewhat gregarious in its habits when living, for upwards of twenty specimens of it are exposed on the surface of a large slab of shale collected by Dr. Ami at this locality, and fourteen upon that of another. It is associated with numerous species of Trilobites, Brachiopoda, etc. All the specimens of *A. Canadensis* are crushed quite flat laterally, and occur as obscurely defined and extremely thin carbonaceous impressions of the body-segments, with the tail (the latter usually a little twisted) on each of the surfaces exposed by splitting pieces of the shale.

"The generic name *Anomalocaris* (from ἀνομοιος, 'unlike'; καρις, 'a shrimp'; i.e. unlike *other* shrimps) is suggested by the unusual shape of the uropods or ventral appendages of the body-segments and the relative position of the caudal spines.

"Ten genera of Phyllocarida have previously been recorded as occurring in the Cambrian rocks of Europe or America. These include *Ceratiocaris*, McCoy (1848), *Hymenocaris*, Salter (1853), and *Protocaris*, Walcott (1884). To these may now be added *Anomalocaris*, which differs from the other three genera of Cambrian Phyllocarids in the following particulars:—In *Ceratiocaris* the caudal appendages consist of a median telson or style and two lateral stylets. Further, although ventral appendages to the body-segments have been discovered in one species of *Ceratiocaris*, the *C. stygia* of Salter, yet these are represented as 'broad and paddle-shaped,' not slender and acutely pointed[1] as in *Anomalocaris*. In *Hymenocaris*, according to Professor H. A. Nicholson, the 'hinder termination of the body is adorned with three pairs of unequal spines,' but in the woodcut of the type and only known species of that genus, the *H. vermicauda*, which is reproduced in so many palæontological manuals, all of these spines are represented as terminal and the body-segments as devoid of any ventral appendages. The first specimens of *Hymenocaris*, by the way, were collected by Dr. Selwyn in 1846 in the Lingula Flags near Dolgelly, Merionethshire. The *Protocaris Marshii* of Walcott, from the Middle Cambrian of Vermont, is described as having no fewer than thirty narrow segments 'between the posterior edge of the carapace and the telson,' and a telson 'which supports two caudal spines.'" (J. F. W.)

We are prevented by want of space from giving, as we had hoped to do, a complete summary of the Mount Stephen fossils, and must here conclude our imperfect sketch of this most interesting fauna, expressing the hope that the Canadian Geological Survey will before long publish the whole series in a monograph form.

[1] After a careful study of Mr. Whymper's specimens I am inclined to think these acutely pointed and spine-like appendages may have been fringed with fine hairs, of which I have here and there detected traces.

References.

1887. R. G. McConnell (Geol. Surv. Canada).—"Report on the Geology of a portion of the Rocky Mountains" (with Section): Ann. Rep., new ser., vol. ii (1886), pp. 1D–41D; Montreal, 1887. "*Olenellus Gilberti*, Walcott (Middle Cambrian), Vermillion Pass (1884), collected by Dr. G. M. Dawson": op. cit., p. 30D.

1887. Dr. C. Rominger.—"Description of Primordial Fossils from Mount Stephens, North-West Territory of Canada": Proc. Acad. Nat. Sci. Philadelphia, 1887, pp. 12–19, pl. i, with descriptions of seven Trilobites from Mount Stephen.

1888. Chas. D. Walcott.—"Description of New Genera and Species of Fossils from the Middle Cambrian": Proc. U.S. National Museum, Washington, 1889 (vol. xi, 1888), pp. 441–446, with descriptions of thirteen fossils, mostly from Mount Stephen.

1890. Chas. D. Walcott.—"The Fauna of the Lower Cambrian or *Olenellus* Zone," in 10th Ann. Rep. U.S. Geol. Surv., 1888–9, by J. W. Powell, Director; pt. i, Geology, pp. 511–658, pls. xliii–lxxvi. Page 538 refers to Dr. G. M. Dawson's discovery of *Olenellus Gilberti*, etc., etc.

1886. Chas. D. Walcott.—"The Cambrian Faunas of North America": Bull. U.S. Geol. Surv., vol. iv (1885–6), pp. 1–226, pls. i–xxxiii.

1888. Chas. D. Walcott.—"Cambrian Fossils from Mount Stephens, North-West Territory of Canada": Amer. Journ. Sci., ser. III, vol. xxxvi (Sept., 1888), pp. 161–166.

1892. J. F. Whiteaves, LL.D., F.G.S.—"Description of a New Genus and Species of Phyllocarid Crustacean from the Middle Cambrian of Mount Stephen, B.C.": Canadian Record of Science, vol. v, No. 4 (Oct., 1892), pp. 205–208, with a text-figure of *Anomalocaris Canadensis*.

1899. G. F. Matthew, D.Sc., LL.D.—"Studies on Cambrian Faunas, No. 3. Upper Cambrian Fauna of Mount Stephen, British Columbia: The Trilobites and Worms": Proc. & Trans. Roy. Soc. Canada, ser. II, vol. v (1899), sect. iv, pp. 39–66, pls. i–iii, vii.

1899. F. R. Cowper Reed.—"A New Trilobite from Mount Stephen, Field, B.C.": Geol. Mag., Dec. IV, Vol. VI (1899), pp. 358–361, with a text-figure of *Oryctocephalus Reynoldsi*, sp. nov.

1902. Professor T. G. Bonney, F.R.S.—"A Sodalite Syenite from the Canadian Rocky Mountains": Geol. Mag., 1902, pp. 199–206.

II.—The Canadian Rockies. Part II: On some Rock-specimens collected by E. Whymper, Esq., F.R.S.E., in the Canadian Rocky Mountains.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

THE Canada Pacific Railway crosses the watershed of the Rocky Mountains at Hector or, as it is sometimes called, Kicking Horse Pass, and the specimens brought back by Mr. Whymper represent a district extending for some twenty miles on each side of the track, either on or west of the divide. The first group was obtained from summits lying near the railway on its southern side. Of these Mount Whyte is about three miles from it on the divide, which is crossed by Pope's Col just to the north of that summit, and about a mile to the north-east of the latter rises Mount St. Piran. About $3\frac{1}{2}$ miles south of Mount Whyte, Mitre Col leads from the Lefroy to the Horseshoe glacier, between Mount Lefroy, which is on the divide, and Mitre Peak on the eastern side of it.

The specimen from the summit of Mount Whyte [2017][1] is

[1] The numbers are those on Mr. Whymper's specimens, which may be understood to have been taken from rock *in sitû*, unless there is an express statement to the contrary.

a nearly white, fairly crystalline limestone, which under the microscope proves to be composed of calcite grains (slightly dolomitic and banded), varying in diameter from about ·0014 to ·025 inch, with a slight brown, feebly pleochroic stain in one or two places, and a few very dark brown specks (? iron-oxide). The fragment from the summit of Pope's Col [2016] is a darkish-grey subcrystalline limestone, weathering to a paler tint, crossed by a thin vein of calcite which slightly projects on a weather-worn surface. Microscopic examination shows it to be a dolomitic limestone composed (except for a slight staining near a vein) of grains fairly uniform in size and often about ·005 or ·006 inch in diameter. The summit of Mount St. Piran [2019] is a rather slabby and banded quartzite of a brownish or purplish grey colour, obviously containing, especially in one band, an iron-oxide which weathers away in brown specks. The microscope shows it to be mainly composed of quartz grains in finer and coarser bands, the former being mostly subangular and often rather less than ·001 inch in diameter. A few grains, however, are a brownish grey colour, and exhibit, with crossed nicols, a minute aggregate structure, possibly resulting from the alteration of felspar; these are from ·025 to ·035 inch in diameter, and usually well rounded. One or two streaky aggregates of chlorite are present, and this mineral can be detected, though seldom, in the last-named grains. There may be a little minute rutile. The quartz cementing the larger grains of the same mineral is in optical continuity with that to which it adheres, though the outline of this is often defined by a line of iron-oxide. Obviously most of the latter was deposited almost simultaneously with the cementing silica. The rock from the summit of Mitre Col [2018] is a rudely prismatic (jointed) fragment of a darkish subcrystalline limestone, with small white spots rather irregular in shape and size. A slice cut parallel with the probable direction of bedding shows a general similarity to that from Pope's Col, except that here and there patches occur composed of grains nearly treble the ordinary diameter, but with no recognizable sign of organic structure. A few dark-brown specks are probably iron-oxide. The summit rock of Mitre Peak [2020] is a rather crystalline, nearly white limestone, somewhat mottled by dull and darkish lead-coloured spots, which is rudely defined by joint and bedding planes. A slice cut perpendicular to the latter shows it to be a crystalline limestone, almost without sign of dolomitization. Grains about ·015 inch in diameter occur in patches, the rest being about half that width. Some small grains and specks of iron-oxide are present.

The next group of specimens come from the neighbourhood of Mount Ball, which rises on the divide a little to the south of Vermillion Pass and about 26 miles S.S.E. of Hector Pass. Of these [2010], [2012], and [2014] come from a valley on the east side of the divide which leads from the north to Mount Ball. The first, labelled "from the great boulder," is a pale-grey subcrystalline limestone, with minute crystals sparkling in a compact matrix, like that of some of the purest British Carboniferous limestones. The

second is a dark limestone, probably tinted by carbonaceous matter and not very pure, which assumes a brownish tint in weathering. On one side portions of four trilobites are exposed.[1] The last number covers three specimens from the moraine of the glacier in Ball Valley. One is a rather dark limestone, compact in structure, not unlike some of our Carboniferous limestones, in which are some irregular white spots and occasional white streaks up to about a quarter of an inch in length; a second is not quite so dark, but has only a few small spots; the third (smaller) is a prism with natural faces, paler in colour. These two much resemble specimens of British Carboniferous Limestone. A slice from the first shows a mosaic of grains, rather variable in shape and size, and ranging from about ·0025 to ·005 of an inch in diameter. Most of them are crystalline calcite, but the brighter tints of some suggest the presence of dolomite, or possibly chalybite. The white spots prove to be irregular aggregates of similar but larger grains, often about ·02 inch in diameter. The matrix includes a few crystalline grains of a clear colourless silicate, two of which, about ·025 inch long, are fairly idiomorphic, being bounded by edges in the prism-pinacoid zone, and those of pyramids or domes meeting at an angle of about 70°. They extinguish at a small angle, about 5°, with the former lines, include a few granules of calcite, and probably are a secondary felspar. [2015], from the summit rock of Ball Pass, is a compact darkish limestone, bounded by four rhomboidal joints, and showing at right angles to these slight signs of lamination. Under the microscope this structure is more conspicuous, for it proves to be composed of granules of calcite, with a faint staining, divided by linear bands of grains, about ·0025 inch in diameter, separated by a dark-brown material, and presenting a slightly fragmental aspect. A number of minute cracks, filled with more coarsely crystalline calcite, run at high angles to the banding. This specimen may have been affected by a shearing crush. [2013], from the summit of Mount Francklyn, which rises just north of Vermillion Pass, is an oblong slab, four of its surfaces being natural; apparently it is a compact, rather muddy limestone, a dull grey, weathering brownish, in colour, with a faint and slightly wavy cleavage, which makes an angle of about 25° with the (natural) top and bottom surfaces of the slab.

The next group of specimens comes from the Mount Stephen district. This peak lies a short distance to the E.N.E. of Field (4,026 feet), which is a station on the Canada Pacific Railway a few miles west of the divide. [2011], "from a height of about 6,000 feet on this mountain," is a rather slabby, dark calcareous mudstone, something like Llandeilo Flag, but weathering to a browner tint.[2]

Cathedral Peak [2035], E.N.E. of Mount Stephen (but also west of the divide), is a stratified limestone, the broader bands darkish grey, the thinner weathering to a browner tint, but little streaks with a similar habit occur in the other. Dennis Pass is to the south

[1] For a description of these by Dr. H. Woodward see pp. 536 and 541.

[2] For a description of the fossils on it see Dr. Woodward's paper, pp. 529–543.

of Mount Stephen, between it and Mount Dennis. The rock from the summit [2021] is a flattish slab, formed by a vein of quartz, from about a quarter to nearly half an inch in thickness, slightly iron-stained on both sides, with a little pale greenish-grey phyllite adhering, in which are some more distinctly micaceous streaks, the rock no doubt having been much affected by pressure. On the west bank of the Kicking Horse River, facing Mount Stephen, is Mount Burgess. From the summit one of Mr. Whymper's guides brought a piece of dark grey limestone [2039] resembling one from our Lower Carboniferous. Under the microscope it is found to consist of minute grains of calcite, of a pale brownish-grey tint, in which thin brown lines indicate a rude cleavage; two or three cracks being filled by calcite. It is probably a pressure-modified limestone. From the base of the mountain, about one-third of a mile from Field and nearly at the level of Hector Pass, two specimens were collected from rock exposed in blasting a road to the Emerald Lake. One is a chip of rather dark compact limestone, weathering to a paler tint, not unlike the summit rock; the other is a similar rock, but covered in parts with a tufaceous deposit. Mr. Whymper remarks that round about Field, or, indeed, at most places in the Rockies, which have nearly the same elevation above the sea, it is very difficult to find rock *in sitû*, for it is masked by forest or buried under vast quantities of soil or débris.

The next specimens come from mountains some fifteen miles to the north-west of Field and to the south-west of Mount Collie, or from a mass forming a kind of spur between two tributaries of the Columbia River, namely, Kicking Horse River on the south and Blaeberry Creek on the north. The summit of Mount Marpole [2022] is a dark grey compact limestone, which weathers to a pale brown colour and shows on a polished surface numerous small spherical bodies, of a yellowish-brown colour, often with a greyer central spot, which have some resemblance to the grains of an oolite, but weather out more quickly than the rest of the rock. The matrix under the microscope is formed of calcite grains, perhaps slightly dolomitic, somewhat variable in size and shape, and enclosing a number of rather oval bodies about ·05 inch in longer diameter, commonly composed of an outer shell of grains (diameter about ·001 inch) with an approach to radial arrangement, and a core of smaller grains and granules, with a little interstitial brown colouring (? bituminous). Here and there we find a grain, neither composite nor so large, suggesting, but not conclusively, an organic origin. The rock seems to have undergone a considerable amount of mineral, followed possibly by some mechanical change. The summit of Mount Kerr [2023] is a very similar rock, but with rather smaller and paler-coloured spots, which under the microscope are seen to be approximately spherical and composed of grains of calcite, outlined, and even faintly tinted, by brownish material, embedded in clear granular calcite, much of the same size, a little dolomitic, and showing a slight bending of the cleavage planes, indicative of strain. Probably both these rocks are somewhat

altered oolites. Dr. Collie brought back a fragment (loose) with a similar structure from the district considerably farther north. From the foot of these mountains Emerald Pass leads eastwards to Emerald Lake. The rock from its summit [2024] is a pale grey, very compact limestone, like one of the purest English Carboniferous limestones, with rhomboidal jointing, weathering buff colour, and developing a fine, slightly wavy banding. The structure, on microscopic examination, proves to be due to coarser and finer grains of calcite, slightly dolomitic. Two or three irregularly outlined, larger grains are suggestive of an organic origin. Other scattered specks and grains occur, the latter hematite. Mount McNicoll is near Emerald Pass, and its summit [2027] is a greyish limestone, which, from its brown weathering, must contain a fair amount of iron. It has a rather earthy odour and effervesces, but not very briskly, with H Cl, and is probably not very pure. The rock [2028] from the summit of the pass between it and Mount Shaughnessey is not quite so ferruginous as the last, but otherwise is in all respects similar. The summit of Michael's Mount [2029], part of the same massif, is a cream-grey subcrystalline limestone, with faint rust-brown spots and a few irregular patches of a darker grey colour. The structure proves on microscopic examination to be rather irregular. Grains of calcite, occasionally dolomitic, differing considerably in size and arrangement, predominate; the larger sometimes forming little clusters with a pale-brown staining, which vary from rather irregular to oval in outline, and sometimes grouped in a way suggestive of the former presence of fragments of shells, etc. Rather irregularly distributed among this, and sometimes aggregated, are small grains of a clear silicate, a few of which are partly idiomorphic and exhibit twinning, Carlsbad or oscillatory. Probably they are a secondary felspar, and a few dark specks are iron-oxide.

Nearer to Mount Collie, on the north side of the Upper Yoho Valley, are the following peaks: Mount Pollinger [2025], Mount Kaufmann [2026], Insulated Peak [2030], and Yoho Peak [2032]. The summit of the first is a pale-grey subcrystalline limestone, with some resemblance to one of the dolomitic limestones of the Alps, but becoming browner on weathered surfaces. Mount Kaufmann is a grey limestone, showing thin bands differing in texture from the rest, and projecting slightly from weathered surfaces. Insulated Peak is a subcrystalline limestone of a grey colour, slightly streaked with white, and showing faint traces of small spots, which weather brown. Under the microscope it is found to consist of grains (a large number being about double the size of the others), more or less dolomitic, of a faint brown colour, with a slight pleochroism in which, as a matrix, are occasional irregular stain-like spots of a dirty brown colour (? bituminous). There are also a few minute interstitial granules of a water-clear silicate, and the rock more nearly than usual approaches to a marble. Yoho Peak is a grey subcrystalline limestone, assuming a buff tint on weathered surfaces and veined with calcite. The summit of Trolltinderne, a mountain on the eastern side of the Yoho Valley and just west of the water-

shed, is a rather dark grey limestone, with moderate effervescence, showing on a smooth surface a rudely banded, almost fluxional structure in the form of darker and lighter streaks. Microscopic examination proves it to be a mixture of dirty granular calcareous material, and of a less abundant clear silicate in small grains, and a few flakes, probably of white mica, with sundry brown and blackish specks like iron-oxide; the whole traversed by rather irregular dark lines, indicative of a rude cleavage. The clear silicate sometimes includes very minute rhomboidal scales, and as one or two grains of it show a distinct oscillatory twinning, it is probably a plagioclastic felspar. The glacier which feeds the Yoho River descends from Mount Collie [2033] and Mount Habel [2031], a summit about $1\frac{1}{2}$ miles to the south-west of the other. The summit of Mount Collie is a compact, subcrystalline, not very dark grey limestone, weathering to a browner tint, with faint traces of minute spots which become more conspicuous by forming holes on a weathered surface. As effervescence with H Cl is slower than one would anticipate, the specimen is probably dolomitic. The summit of Mount Habel is a grey subcrystalline limestone, full of very small spots, rather irregularly distributed, and weathering to a pale brown colour, containing also a few white calcitic grains without definite form or size, the largest of which are about ·2 inch in diameter. The microscope shows it to be a rather dolomitic limestone, with occasional coarser spots and little patches of brown staining. Here and there the former presence of an organism is suggested, and some rather cylindrical clear bodies, in which granules of the carbonate are embedded, have a very faint resemblance to sponge spicules. Extinction is parallel to the edges, so that if only mineral in origin they may be allied to couseranite.

The specimens from the Ice River Valley, chiefly crystalline rocks and in many cases sodalite or nepheline syenite, have been already described in the Geological Magazine for this year (p. 199).

Specimens from the Hoodoos (earth pillars) of Leanchoil (on the Canada Pacific Railway) [2040] are a pale yellowish clay and a small grey limestone pebble, clearly water-worn, but not in any way remarkable. The former consists of minute micaceous and clayey material, mixed with small angular rock-fragments, stained a rather rusty tint, and difficult to determine exactly — not improbably a siliceous mudstone. Few, if any, quartz grains occur in the mud, which otherwise is not remarkable. It effervesces slightly with H Cl, so the material is probably derived from argillites and limestones.

The above descriptions show that [2107] and possibly [2020] approach the structure of a true marble, such as that of Carrara, or one of those interbanded with crystalline schists in the Alps. Most of them are not more altered than specimens from the Dolomites of the Italian Tyrol (to which one or two of them have some resemblance) or than some of the Triassic rocks from the Swiss Alps. Others resemble Carboniferous Limestone from Britain, and the Trilobites from near Mount Ball and from the flank of Mount Stephen are in excellent preservation. But, though I have sliced

practically every specimen of limestone which seemed at all likely to contain fragments of organisms, not a single one has yielded anything of which I could be sure. Yet I have found these in very disturbed districts of the Alps, not only in the noted schistose Jurassics of the Lepontine group (containing belemnites, crinoids, etc.[1]), but also in Triassic limestones near Bergün. With one exception (and this may be due to contact metamorphism, such as must occur in the Ice River Valley), these specimens apparently are not older than Palæozoic times, and in some cases might even be Mesozoic. Hence, as the limestones are numerous, the absence of organisms is so singular that I can only suppose they have disappeared in consequence of micromineralogical changes, as, I believe, has happened with a Triassic limestone near the Pas de Chèvres, Arolla, of which I was more than once reminded by some of these specimens.

III.—The Geology of Barbados.

By Prof. J. B. Harrison, C.M.G., F.G.S., and A. J. Jukes-Browne, B.A., F.G.S.

THE August number of the Quarterly Journal of the Geological Society contains a paper on this subject by Dr. J. W. Spencer, who believes that the rocks which were described by us under the head of 'Raised Coral Reefs'[2] do not form one continuous succession of Pleistocene reef-rocks, but consist of several different limestone formations. He thinks that there are three such formations, and that each is separated from the other by a break or unconformity.

It is, of course, quite possible that the more recent reefs may partially conceal a formation which escaped our notice, and that Dr. Spencer might have obtained evidence of its existence; but before he can establish the existence of an Oligocene limestone in or below some part of our Coral Reef Series, and as a consequence alter the accepted age of every rock-group in the island, he must produce very strong evidence for his innovation.

We fail to find any such evidence in his paper; thus, the only evidence for the Oligocene age of any of our 'reef-rocks' is the occurrence of two corals, unnamed species of *Stylophora* and *Astrocœnia*, which are said by Dr. T. W. Vaughan to be the same species as occur in a limestone of Oligocene age in Antigua. These were only found at one place, a spot near the Cathedral at Bridgetown, and this is absolutely all the palæontological evidence which Dr. Spencer has to offer in support of his conclusion that there are Oligocene limestones in Barbados comparable with those of Antigua.

Beds exposed in a railway cutting not far from Ragged Point, on the eastern side of the island, are referred to this Oligocene formation solely because they show an apparent dip of 15° to 20° and pass below a later horizontal calcareous deposit. No fossils are recorded either from the newer or the older rock, but it is stated that the latter includes a bed which contains masses of corals.

[1] Quart. Journ. Geol. Soc., 1890, vol. xlvi, p. 213.
[2] Quart. Journ. Geol. Soc., 1891, vol. xlvii, p. 209.

Specimens were taken by Dr. Spencer, but they were unfortunately destroyed by accident before they could be named.

Finally, all the higher reefs are considered to be of Oligocene age, because the author says that they show a decided dip to the south-east, and asserts that some of the fossils obtained by ourselves and others are Oligocene species. His own collections were destroyed as above-mentioned, and his statements about the range of the species identified by Professor Gregory [1] are confused and inaccurate. Professor Gregory identified 13 species of Corals from high-level localities, and of these 11 belong to recent species (10 being also found in the low-level reefs of the island); one is a new species for which the only other locality yet known is Ste. Croix in Trinidad, and one (*Lamellastræa Smythi*) is an extinct Antiguan species.

It is true that several of the species found in Barbados occur also in the Antiguan limestones which Dr. Spencer refers to the Oligocene, but as they are also recent West Indian corals they cannot be cited as evidence for the Oligocene age of the Barbadian reefs; clearly such species might occur in beds of any age from the Oligocene to the present time. *Cyphastrea costata* is one of these; Dr. Spencer also quotes *Astræa barbadensis* (Duck. & Mich.) as a link between the 'Oligocene' rocks of the two islands, but Professor Gregory has identified this form with *Orbicella acropora* (Linn.), which is a recent West Indian coral and is found also in the low-level reefs of Barbados.

Dr. Spencer admits that the assemblage of corals obtained from the high-level reefs is sufficient to prove the existence of Pleistocene reefs at such levels, but having persuaded himself that there is a mixture of Pleistocene and Oligocene forms among them, he actually explains this supposed mixture by suggesting that the Pleistocene forms came from patches of Pleistocene reef-rock lying in hollows or pockets excavated out of Oligocene limestones!

As the corals examined by Professor Gregory came from nine different high-level localities, Dr. Spencer would have us believe that in each case a pocket was rifled, and not what he imagines to be the main limestone mass. If he had been more careful in his analysis of the coral species he would have discovered that the single restricted Oligocene species was obtained from only one locality, namely, Castle Grant, but he was so convinced that the mass of the high-level limestones must be of Oligocene age that he throws doubt on all the localities and on all the collections that have been previously made, in spite of the fact that no essentially Oligocene species were obtained from other localities.

Further, one would have expected that before he put such a suggestion into print he would have made very sure of his facts; in other words, that he would be prepared to point out exactly where such pockets occur, what species of corals they contain, and how the rock of the pockets differs from the hypothetically older rock in which he says they lie. Dr. Spencer, however, has not done this; all he says on the subject is to be found in the two paragraphs which are quoted below—"I am

[1] Quart. Journ. Geol. Soc., 1895, vol. li, p. 255.

inclined to explain the occurrence of the seven identical species at the higher levels and at Bath, as having been obtained from remnants of the newer formation filling hollows in the eroded surface of the older high-level limestones. This feature may be seen in ascending the western side of the island, where pockets rich in corals form a contrast with the prevailing scarcity of organic remains of the older formation" (p. 359).

"Without entering into the question of what terraces are due to marine erosion, leaving sea-cliffs in the rear of them, and what are constructional from the building up of reefs, it may be said that these deposits of recent coral-species are wide-spread over the surface, not merely below the altitude of 165 feet, but possibly (in part at least) at the higher levels, where pockets of coral-masses containing recent species occur" (p. 362).

It will be noticed that Dr. Spencer contents himself with stating that such pockets exist on the western side of the island; he does not say where, nor at what levels, nor what species of corals they contain. He adduces no evidence to show that the pockets he saw are of widely different age from the surrounding rock.[1]

Further, he does not offer any evidence to prove that the inclined beds in the railway cutting are of the same age as the high-level limestones, nor any evidence that either the former or the latter are of the same age as the rock near the Cathedral which yielded species of *Stylophora* and *Astrocœnia*. Yet he does not hesitate to tell us that these three sets of beds belong to one series, that this series is of Oligocene age, and that it belongs to what he calls the 'Antiguan formation.' We think that further comment on these points is needless.

We next address ourselves to the attempt made by Dr. Spencer to establish an intermediate formation between the rocks which he regards as Oligocene and those which he admits to be Pleistocene. Here, again, his methods are just as unsatisfactory, and are not calculated to inspire confidence in his stratigraphical work.

The beds which he refers to his 'Ragged Point Series' are nowhere stated to be more than eight feet thick, and no fossils are recorded from them, so that he starts by erecting a few scrappy local deposits into a 'series,' without a single fossil to show whether it is of marine or terrestrial origin. He mentions several places where marls containing pebbles of older limestone rest unconformably upon such limestone (our reef-rock), but there is nothing to prove that these marls are marine deposits. They might be Pleistocene rainwash for all the evidence he gives, but we cannot assert them to be such without special examination of them.

We are quite prepared to admit that the mechanical deposit shown in his Fig. 1 must be of later date than the limestone on which it rests, but we cannot accept his dictum that it is older than the reefs which he allows to be Pleistocene. He only mentions one place where he believes such a superposition to be visible; this is near Bath,

[1] A coral-reef is a composite mass of rock, and portions of it are often differently made up and are more fossiliferous than other parts of the same reef.

and of it he writes, "at the foot of the terrace north of Bath . . . . is a horizontal bed of sand containing small rounded pebbles of the harder old calcareous rocks and lumps of the Oceanic Clay. This stratum is succeeded by a coral-formation," which he calls the Bath Reef Series. He gives a diagram of this section showing Pleistocene coral-rock overlying, with apparent conformity, four or five feet of stratified sand which contains pebbles of an older limestone, and he assumes that this sand is of the same age as the mechanical marl of his Fig. 1, though the places are nearly two miles apart and the material of the two deposits is totally different.

Apparently his only reason for correlating these two deposits is that both contain pebbles of an older limestone, and he jumps to the conclusion that these pebbles have been derived from the same set of rocks, for in the legend of his Fig. 2 he describes the calcareous pebbles in the Bath deposit as "rounded pebbles of the White Limestone" (i.e. his Oligocene Antiguan formation). Now this section is known to us, and the limestone pebbles are certainly there, but all those which we obtained were fragments of the yellowish *Globigerina* limestone of the Bissex Hill Beds; many of them contain casts of small cup-shaped corals which are common in the *Globigerina* limestone, but which Prof. Gregory was unable to name.

Dr. Spencer does not mention the Bissex Hill Beds, which were established in 1898 as a separate group of intermediate age between the Oceanic Series and the Coral Reef Series,[1] so that we do not know how he would group them, but the rock is very different from those which he refers to the Oligocene.

It is quite possible that fragments of the older reef-rocks may also occur in the basement-bed of the Bath reef, for that is a low-level reef, only 150 feet above the sea, and may well contain débris from the higher and previously uplifted reefs; but what then? Dr. Spencer's reasoning seems to be as follows:—No. 1 is a mechanical deposit, No. 2 is a mechanical deposit, both occur at about the same level, and both contain pebbles of older limestones; therefore, both are of the same age! We cannot accept such an argument as having any logical value.

From the above remarks it will be seen that Dr. Spencer's evidence completely breaks down: he fails to connect the basement-bed near Bath with his Ragged Point marl; he fails to show that the latter is older than the Pleistocene reefs, or that it is anything but a superficial terrestrial deposit. In point of fact he fails to establish his 'Ragged Point Series' as an independent formation. We are quite aware that there are mechanically formed calcareous deposits of terrestrial origin in many parts of the island, and they have probably been formed at different times during the gradual upheaval of the area, but if Dr. Spencer's methods were followed it would not be difficult to make out five or six 'formations' or 'series' in the later rocks of Barbados or in those of any other raised coral island.

[1] See Messrs. Franks & Harrison, "On the Globigerina Marls of Barbados," in Quart. Journ. Geol. Soc., vol. liv, p. 540.

Finally, we must express our grave doubts about the high dips which Dr. Spencer states that he saw in our Coral Reef Series. One of us resided for ten years in Barbados, traversed it in many directions at various times, and examined nearly every gully in the island as well as most parts of the great limestone escarpment, yet he never saw any such high dips as Dr. Spencer mentions, except where there was reason to suspect a landslip, and such landslips are certainly common. We have noted low dips (of 4° or 5°) at a few places, and some false-bedding which might mislead an inexperienced observer but hardly one of Dr. Spencer's experience. We cannot say that the high dips are always in slipped masses, but we do think that the sloping beds specially mentioned by him near Bath, "upon the flank of the mountain behind" the Bath Reef terrace, are in a mass that has slipped from the great escarpment above.

Let our readers consider also what continuous dips of from 12° to 20° involve; a dip of 15° continued for only one mile on the horizontal will bring in a thickness of 1,367 feet, and even if the surface of the ground fell 300 feet in the direction of the dip, it would leave a thickness of over 1,000 feet, whereas the greatest thickness of combined Bissex Hill Beds and coral-reef limestones proved by Mr. Easton's numerous borings all over the island is only 280 feet.

It will be obvious that the differences between Dr. Spencer and ourselves are so great and so difficult to reconcile that we are not likely to convince one another by argument at a distance from the field of dispute. Fresh observations are required, and above all further collection of fossils must be made, before either party can make any real addition to our knowledge of the geology of Barbados. We have been in communication with Dr. Spencer, and we hope that one of us may be able to meet him in Barbados next March, with the view of discussing the evidence on the spot and of obtaining fossils from the beds which he regards as of Oligocene age. In the meantime we ask our readers to suspend their judgment on the questions raised by Dr. Spencer's paper.

IV.—The Term 'Hemera.'

By S. S. Buckman, F.G.S.

NEARLY ten years ago I proposed the term 'hemera.'[1] The term is coming into use; but, so far as I am aware, in the majority of cases it is greatly misunderstood. From this cause arise objections as to its use, such objections being based on the misconception that the hemera is a subdivision of a zone. It is nothing of the kind.

The original description may be quoted. "It is for a palæontological purpose that I propose the term 'hemera.' Its meaning is 'day' or 'time'; and I wish to use it as the chronological indicator of the faunal sequence. Successive 'hemeræ' should mark the smallest

[1] "Bajocian of the Sherborne District": Quart. Journ. Geol. Soc., 1893, vol. xlix, p. 481.

consecutive divisions which the sequence of different species enables us to separate in the maximum developments of strata. . . . . The term 'hemera' is intended to mark the acme of development of one or more species. It is designed as a chronological division, and will not therefore replace the term 'zone' or be a subdivision of it, for that term is strictly a stratigraphical one." [1] "The proposed term 'hemera' is used in a chronological sense as a subdivision of an 'age.'" [2]

These statements should be definite enough. They show that while there were the stratigraphical terms 'zone,' 'stage,' and the chronological term 'age' for the time of a 'stage,' there was no chronological term to denote the time of a 'zone.' So 'hemera' was proposed to supply the deficiency. 'Hemera,' 'age' are the time terms; 'zone,' 'stage' denote the amount of work done in the way of deposition during these times: they are the stratigraphical terms. As I said, a hemera marks the acme of development of one or more species, as a chronological term. Just as a 'day' marks the phenomenon, sunrise, high noon, sunset, or, if one likes to put it so, from sunrise to sunrise again, so a 'hemera' was designed to mark the time from species-rise to species-rise—that is, from the time when one species or set of species becomes dominant to the time when another species or set of species does so. Such time intervals were to be termed 'hemeræ.' And so many 'hemeræ' make an 'age,' just as so many 'days' make a 'week.' However, as 'hemera,' 'age' must be of universal application and always have existed, 'zone,' stage' may be absent locally: either there may have been no strata deposited, or the strata may have been destroyed. At one locality may be seen the strata of the zones A, B, C, representing the work done during the hemeræ A, B, C. At another locality may be observed only the strata of zones A and C. One may rightly say that zone B is absent; but one cannot say that hemera B is absent. Hemera B has been proved as a time-period between hemeræ A and C, by the records at one locality of work accomplished. Therefore, absence of records at another locality cannot show non-existence of time. Time is not local. A man cannot say that there was no Monday in the week because the parish clock happened to be out of order. Yet remarks similar to this, made in regard to hemeræ, are what I have to protest against. "Absence of any hemeræ would not indicate a break in the series of strata" is a sample. A Dorset labourer once came to his master and complained, "Sir, your dawg a bin an yet my fittle." He indicated exactly the agent of destruction. He knew that the deposit (of his dinner) in a particular place had been duly made. He was aware, by facts *subjecta fidelibus oculis*, what agent had been concerned in its removal. And he said so; in effect he said, "There is a break in the series of my dinners due to destruction by a certain agent." But had he employed the language which is used about a hemera he would have said, not "My dinner is gone," but "One o'clock is absent"—"The absence of one o'clock indicates a break in

[1] Op. cit., pp. 481, 482. [2] p. 518.

the series of my dinners." But one o'clock is just what cannot be said to be absent—dinner or no dinner one o'clock must arrive.

So to return to the localities mentioned above: what has to be said with regard to the second is that during hemera B either there was no deposit or there was denudation of a deposit, according as the evidence may warrant.

Since hemera has nothing to do with zone properly speaking, so it has nothing to do with subzone. It has been supposed that hemera is a sort of finer division of a subzone. But it is not. Strictly speaking, there should be just as many zones as there are hemeræ; for the hemera is the time during which a certain piece of work, namely, the deposition of what is called 'the zone,' was done. But it may be said that zones coalesce. I confess to a deal of scepticism about this; for, generally, careful work shows that very attenuated as the deposits may be, yet there are the zones in order of superposition characterized by their distinct faunas. When there is coalescence it is more of the lion and the lamb kind, with the lamb inside: the earlier zone in pieces in the later one. Such is the case in the Radstock district in the Middle Lias, where the *raricostatus* beds occur as pebbles in the *armatus* zone. Here the value of the term 'hemera' is seen. One cannot talk of the *raricostatus* zone at this place, because there is really no such zone; but one can say that the strata deposited during the hemera *raricostati* were broken up and redeposited during the hemera *armati*.

Much of the trouble about zones and hemeræ has arisen from attempts to make the term 'zone' a kind of 'portmanteau word,' one into which several meanings were to be packed. Thus, a 'zone' has been spoken of as a 'zone of life,' as a 'band of deposit,' as a 'portion of geological time.' A 'zone' has even been defined as an "assemblage of organic remains"—which would make the contents of a museum a 'zone.' Now in scientific work we cannot have several meanings packed into one word; and so to take away the portion-of-time idea the term 'hemera' was proposed.

With the life-zone idea there is more trouble. In zoology the zone indicates the horizontal extension of species; it might be required and used in this sense in geology; but the life-zone in geology has reference to the vertical range. Why cannot we call this a *biozone*, using the term to signify the range of organisms in time as indicated by their entombment in the strata? Thus we might have the biozone of a species, of a genus, of a family, or of a larger group. Thus the biozone of the Trilobita would be, say, from Cambrian to Carboniferous; the biozone of Ammonites would be equal to Mesozoic time; the biozone of an Ammonite family, Arietidæ, would about equal the time of the Lower Lias; the biozone of an Ammonite genus, *Coroniceras*, would be through two or three hemeræ; the biozone of Ammonite species would be about equal to a hemera.

Then we are left with zone in its stratigraphical sense, best defined by Mr. J. E. Marr. But we have no business to use it for this, because of the zoological meaning which the term already has.

Now we cannot separate the stratigraphical from the palæontological phenomena; the two go together. Zones are not bands of rock merely, for the strata of a zone may be heterogeneous vertically or horizontally. The zones are really so many entombments of organisms, which entombments are shown to be successive by the way in which they occur in the strata. For these successive entombments as they are exhibited in the strata, why should we not use a term *faunizone*? With distinct terms for the different meanings we shall express ourselves much more clearly.

To return to hemera, I have been asked if it is advisable when faunas differ, and when the index species is absent, to use different names as hemeral designators. I say that it is not advisable. Temp. Edward VII may date an event in Australia as well as in England, even though Edward VII never visits Australia. So hemera *Murchisonæ* will date a deposit in a locality where *Murchisonæ* never resided.

Certainly in historical records each nation has dated its events by the reigns of its own monarchs. Yet it would, in the interests of a universal system, be quite correct, from a chronological point of view, to say that certain events happened in Spain temp. Queen Elizabeth (of England). It is the aim of science to be universal and independent of nationalities. It is the aim of geology to have a universal chronological system, not to apply different and therefore confusing names to contemporaneous periods of time merely because of local faunal differences. And when, as in the Jurassic rocks, the sequence of faunal phenomena from Würtemberg to England can be accurately described by one set of hemeral terms, we may reasonably hope that, as our knowledge increases, if we take the necessary trouble, a universal chronology may be possible. And if that can be done in the Mesozoic rocks how much more may we not expect it in the Palæozoic, seeing that, as Dr. H. Woodward tells us, "the ancient faunas of the earth were far more widespread, more simple, and more uniform than are our recent faunas." [1]

To sum up, a *zone* indicates the horizontal extension of species, and so is a geographical term; a *biozone* is the range of any organism or group of organisms in geological deposits, so it may be said to indicate vertical extension; *faunizones* are, to paraphrase Mr. Marr, "belts of strata, each of which is characterised by an assemblage of organic remains," with this provision, that faunizones are independent of lithic structure—the strata of a faunizone may vary horizontally or vertically, or the strata may not vary and yet may show several successive faunas. So faunizones are the successive faunal facies exhibited in strata. Lastly, *hemera* is a time term—the subdivision of an 'age'; it indicates the period of time from the rise of one dominant species to the rise of the next. It is the time term which corresponds to 'faunizone' as the stratigraphical term, just as 'age' corresponds to 'stage.'

[1] Anniversary Address of the President to the Geological Society, Q.J.G.S., vol. li, p. lxxxvii.

NOTICES OF MEMOIRS, ETC.

I.—The Conditions under which Manganese Dioxide has been deposited in Sedimentary Rocks, as illustrated by the Elgin Sandstones. By William Mackie, M.A., M.D.[1]

MANGANESE dioxide has been observed to occur in the Elgin Sandstones under the following conditions:—(1) In ovoid or rounded spots, from $\frac{1}{2}$ inch to 6 inches in diameter, known to the quarrymen as 'vegetations,' at Newton Quarry, in U.O.R. rocks. From analyses MnO_2 varies from ·18 per cent. to ·262 per cent. (2) In small nodules, about $\frac{1}{4}$ inch in diameter, in Triassic rocks, south-east of Cuttishillock, $MnO_2 = 12{\cdot}87$ per cent. (3) In punctiform spots around decomposing felspars in sandstone of the Rosebrae division, U.O.R. sandstones = ·0715 per cent. of MnO_2. (4) In small spots or lining minute cavities, and evidently following carbonate of lime in Triassic rocks, at Spynie and Lossiemouth, MnO_2 = ·035 per cent. (5) In veins or lining joints, occasionally parallel to and some distance back from the joint-plane. An example from Bishopmill, U.O.R., gave MnO_2 1·27 per cent. + MnO ·27 per cent. (6) Along the upper surface, and occasionally irregularly diffused through the interbedded clayey bands of the Rosebrae division. (7) Uniformly diffused through the sandstone in the same way as the much more frequently occurring ferric hydroxide; seen at Newton, Millstone, and Cloves quarries in the U.O.R. (8) In some organic remains in the same formation; a scute of *Bothriolepis major* gave MnO 2·33 per cent., of *Psammosteus Taylori* ·83 per cent. (9) As a brown or blackish staining on the casts of organic remains. (10) As illustrative examples are cited fragments of cherty limestone in the local Boulder-clays, with their interstices filled with MnO_2, the carbonate of lime having been totally removed, and a specimen of 'black' sand from under Boulder-clay on the Banffshire coast, MnO_2 6·58 per cent. + MnO ·48 per cent.

Experiments made by allowing a dilute solution of manganese sulphate—thirty grains to the gallon—to drip slowly on various rocks and sandstones showed that common chalk and sandstone containing carbonate of lime were darkened in colour within twelve hours. Sandstones without carbonate of lime were not darkened. If the specimens were first moistened with dilute ammonia, caustic soda or potash, or the carbonated alkalies, darkening to a degree, took place very rapidly. Free ammonia was found to exist in every specimen of sandstone from the area examined, and to be particularly plentiful in Newton sandstone. An acid reaction was obtained in some of the 'black' spots at Newton, due, it was believed, to the oxidation of sulphur, which was also present. Others gave a marked alkaline reaction. The presence of ammonium chloride was also demonstrated in a number of the sandstone specimens. In the presence of ammonia and ammonium chloride, manganese is only precipitated after it is peroxidized, but peroxidization is rapidly effected in the presence of free ammonia or other free alkali.

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

Though the solution of ammonia and ammonium chloride in the sandstones is no doubt very dilute, it is probably, as compared with the solution of manganese in the infiltrating water, relatively strong.

Presuming the access of oxygen—which may be taken for granted in the case of porous rocks like sandstones—the explanation of the precipitation of manganese dioxide simply resolves itself into accounting for a preponderance of alkalinity at the special points of precipitation of that substance. Analyses show that the manganese areas contain excess of lime, magnesia, and alkalies, compared with what obtains in the surrounding sandstones. This may have been a cause of increased alkalinity, and hence of the precipitation of the manganese dioxide. On the other hand, it may simply be a concomitant of the precipitation, and due to the same cause. The alkalinity in some of the manifestations enumerated has undoubtedly been due to carbonate of lime, (1), (2), (4), (8), (9); to the ammonia arising from the decomposition of organic remains, (1), (8), (9); to the presence of carbonated alkalies, (3), (5), (6), (7); and to free ammonia of the sandstone water after the total precipitation of the ferric hydroxide in a higher zone of the sandstones, (7). The conditions that are necessary for the precipitation of manganese dioxide are the presence of alkali or alkaline substance in excess, soluble manganese compounds in transit, and facility for oxygenation.

There is nothing particularly unique in the precipitation of manganese dioxide. It is simply an extension or continuation of the same action as determines the precipitation of ferric hydroxide, and a general separation is effected between the two substances by the fact that the iron compounds fall out before the manganese as the infiltrating water containing them encounters further and further supplies of alkali. The general distribution of the two substances in the Elgin Sandstones illustrates this natural method of separation, the rocks impregnated with secondary infiltration of ferric hydroxide in a general way occurring in a zone overlying those impregnated with manganese dioxide.

In the author's opinion the manganese nodules of the deep-sea deposits owe their origin to the operation of the same or similar causes.

As a general summary it may be stated that the principles involved in Weldon's process for the recovery of manganese were long anticipated, and had long been in operation in Nature's processes before Weldon's day.

II.—The so-called 'Fossil' Water of Sedimentary Strata, as illustrated by the Sandstones of the Moray Firth Basin.

By William Mackie, M.A., M.D.[1]

A SERIES of determinations of the soluble chlorides and sulphates locked up in the interstices of the Elgin Sandstones, was made to test the thesis that from such an examination it is possible to determine the character, as to freshness or salinity, of the waters of the basin of deposit of a series of sedimentary rocks.

In the present case, though some interesting side issues were no

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

doubt made manifest, the results as regards the main issue were found to be entirely negative. In all, 38 determinations were made: 7 in L.O.R. rocks, 17 in U.O.R., 6 in Triassic, 1 in Jurassic, and for the purposes of illustration 7 in recent deposits. The averages obtained were :—

	Cl, per cent.	SO_4, per cent.
L.O.R.	·0101	·0180
U.O.R.	·0077	·0064
Triassic	·0050	·0051
Jurassic	·0037	·0113
Recent	·0049	·0042

Average over all: Cl, ·0063 per cent.; SO_4, ·009 per cent.

Some interest attaches to these averages in relation to the question of the saltness of the sea. They show at least that a fairly large proportion of that saltness may reasonably be referred to the washing out in past times of the chlorides and sulphates from sedimentary rocks.

The increase shown by these averages from the younger to the older formations—or, to put it otherwise, from the overlying to the underlying rocks—may be ascribed to the washing in of the soluble salts from the surface and concentration in the depths; but doubt may be expressed if that covers the whole case.

Remarkable variations were obtained in specimens from the same sandstone, even when collected in the same quarry. These variations were in some cases so extreme as to preclude any general conclusion as to the character of the waters of the basin of deposit. It was also found that the percolation of rain-water may reduce the chlorides to ·0005 per cent. or less, and the sulphates to a like quantity, or even to entire absence. Water passing down joints and fissures, it was also found, tends to wash back the soluble salts and concentrate them at some distance back from the fissures. Chlorides, and less frequently the sulphates, were found to increase in rocks secondarily stained with ferric hydroxide, and also in the manganese areas. It has been shown elsewhere that traces of the heavy metals are disseminated through the Elgin Sandstones generally, and also tend to increase in relative proportion in the manganese areas. Increases in lime, magnesia, and alkali have also been demonstrated as obtaining in the same areas. From the intimate relationship of all these substances it is inferred, with some degree of certainty, that they formed part of the same general infiltration. If so, it must also be inferred at the same time that the original 'fossil' water of these sandstones must have long ago been washed out, or at least seriously masked in the process. Generally it may be said that such washing out of the original 'fossil' water may have taken place anywhere, and that the result of subsequent infiltrations may have themselves been replaced again and again by other infiltrations, and so on. The inference, therefore, that the soluble salts of a series of deposits represent the salts of the original waters of the basin of deposit must in the majority of instances be a very uncertain one, if indeed any degree of certainty can be claimed for such an inference under any circumstances.

III.—Short Notices.

1.—A Backward Step in Palæobotany. By G. F. Matthew, LL.D. Trans. Roy. Soc. Canada, ser. II, vol. vii, sec. iv, p. 113.

Some years ago the late Sir Wm. J. Dawson described a fine collection of fossil plants from a locality near St. John, and on the evidence which he obtained from them stated their age to be Devonian.

Lately, other palæobotanists, Messrs. R. Kidston and David White, reviewing this evidence, have come to the conclusion that these plants must belong to the Coal-measures. The present article is written in support of the original view that these 'plant beds' and their flora are much older.

Evidence is deduced from the stratigraphy that several eroded terranes lie between the true Coal-measures and the 'plant beds,' and that these must be much older than the former.

The composition of the flora is also examined, and it is shown that this series contains a number of genera of plants not found in the Coal-measures proper, and that while a small percentage only of the species of the plant beds are identical with those of the Coal-measures of Pennsylvania, about half of these are found in the European Coal-measures. The connection of the plant beds with the Coal-measures, therefore, seems a distant one.

2. Royal Society's Catalogue of Scientific Papers.—The Royal Society has issued a circular appealing for funds to enable it to carry out the original scheme of cataloguing the papers contained in scientific periodicals up to and including 1900, of which twelve quarto volumes have already been issued, and the work brought down to 1883. The Society has already spent £14,790 5*s.* 5*d.* upon the matter, and now thinks that it might receive a little more financial assistance from others, especially as its expenditure has increased considerably of late years in other directions. They want £12,000, and it should not be difficult to raise the amount. The Society also proposes to issue a subject index for the whole period of 1800–1900, an index which, if properly done, should be of enormous value. It is pleasant to note that both these works are already in hand, and the completion of the author catalogue may be expected in about five years. Dr. Ludwig Mond, who previously gave £2,000, has headed the new list of subscriptions with the magnificent donation of £6,000, and Mr. Carnegie has contributed £1,000. We hope the delicate shade of meaning given to the letters F.R.S. by an eminent expert will be borne in mind by others who have found it an equally valuable asset.

3. North German Lower Cretaceous.—Dr. A. von Koenen has given a revised classification of the Albien in the Nachricht K. Gesell. Wiss. Göttingen (Math.-Phys.), 1901. This includes the Aptien, Barrêmien, Hauterivien, and Valanginien, each of which he divides into upper and lower. In the copy of his paper before us, a separate from the author, we note that he has corrected his

lower Barrêmian by placing the zone of *Crioceras elegans* above instead of below the zone of *Ancyloceras crassum* and *Crioceras fissicostatum*.

4. Chalk Foraminifera.—The foraminifera of the *Inoceramus*-beds of the district of Rzeszow and Debica have been figured and described by W. Friedberg in Bull. Intern. Acad. Sci. Cracovie (Dec. 1901). Out of 92 forms mentioned some 66 were previously found by Grzybowski in the *Inoceramus*-beds of Gorlice (ibid., April, 1901). The figures given by Friedberg are rather rough and unsatisfactory.

5. Patagonian Tertiary Mollusca.—H. von Ihering has an important though short paper on this subject in the Proc. American Phil. Soc., xli (April, 1902). He states that Borchert erroneously determined many of the forms, and thus was led to a wrong idea as to the age of the beds. Ihering regards the Parana formation as Miocene, and the Cape Fairweather beds as the representative of the Pliocene of Argentina in the south, while the same formation in the north is seen in the Tehuelche beds. The 'Pampeano superior' of Ameghino he regards as Pleistocene, and the *Pyrotherium*-beds as Eocene. Ihering says that there are neither existing nor Mesozoic species of mollusca in the *Pyrotherium*-beds.

6. Oligocene and Miocene Deposits of the Great Plains.—Hatcher, in the same Proceedings, discusses the origin of these beds, dealing with the character of the materials and the palæontological evidence. He arranges the White River formation thus: 1, *Titanotherium*-beds; 2, *Oreodon*-beds; 3, *Leptauchenia*-beds. The Loup Fork formation thus: 1, Gering Sandstone; 2, Ogalalla formation. The Arikaree formation thus: 1, Monroe Creek beds; 2, Harrison beds; 3, Nebraska beds of Scott. All from below upwards.

7. The Hull Museum.—Although this museum has been opened but a few months, Mr. Sheppard has already got into excellent shape the collections of Antiquities and Animals. He is now at work upon the geological material. Among this is the collection made by F. A. Bedwell (afterwards Judge) from the Chalk. Bedwell was the author of the paper on the Ammonite Zone of Thanet, which appeared in the Geologists' Association Proceedings, a paper the accuracy of which has been vouched for by Rowe. When Mr. Sheppard has cleaned and arranged this Chalk collection, which no doubt all came from the South of England, he will probably find some interesting specimens, and possibly some types.

8. Geology of Hertfordshire.—Mr. Hopkinson has issued in the Trans. Herts Nat. Hist. Soc., 1902, vol. xi (3), a list of works on the geology of the county from 1884 to 1900. This is in continuation of a previous list, and that again of Whitaker's list of 1875. We wish other county societies would see their way to publish similar lists regularly. A few have done so, but it is not general, and the matter might well engage the attention of the British Association Committee.

9. Pre-Rhætic Denudation of the Bristol Area.—Dr. Callaway deals with this subject in the Proc. Cotteswold Nat. Field Club, 1901, xiv (1). The paper gives a clear sketch of the country before and after Rhætic times, and is illustrated by two sections, one of the Avon section and the other of the Avon gorge.

10. Manchester Museum.—Mr. Hoyle's Annual Report for 1901–2 is highly satisfactory. The Rev. Arthur Dixon has given the museum a fine collection of fossils, rocks, and minerals. Other geological material acquired by gift or purchase is a series of rocks from Charnwood Forest, sections of coal plants selected to fill gaps in the collection, collection of magnesian concretions, of stalagmites and stalactites, Permian rocks from the Lakes and Isle of Man, and cores from borings in the Isle of Man.

REVIEWS.

I.—Geological Survey of England and Wales. Sheet 123 (Stoke-on-Trent). Solid and Drift Editions. Scale, 1 inch to a mile. (Price 1*s.* 6*d.*)

Memoirs of the Geological Survey of England and Wales. The Geology of the Country around Stoke-on-Trent (Explanation of Sheet 123). By Walcot Gibson, B.Sc., F.G.S., and C. B. Wedd, B.A., F.G.S.; with Notes by George Barrow, F.G.S. (1902. Price 1*s.* 6*d.*)

IT is necessary to discuss the Map and Memoir as separate items, because so much of the technicalities of the production of the map is new and important. It is incidentally stated in the preface to the Memoir that "Both maps are colour-printed, and they represent the first attempt to substitute colour-printing for hand-colouring in the issue of the 1 in. Survey maps." We must heartily congratulate those who originated the idea and those who have so ably carried it out, for the result is highly praiseworthy, and may be considered as a triumph of geological map printing. The map will be, at any rate, free from the personal errors of the colourist, and the colours will be both more permanent and will always agree with the colour index in the margin. This improvement, however, carries with it a great reduction in price, the sheet being issued at 1*s.* 6*d.* per copy instead of 3*s.*; and, by the way, the old quarter-sheet at 3*s.* only measured 13½ by 10 inches, while the new sheet is 18 by 12 inches. The new sheet covers a somewhat different area, taking in more ground to the west, and not including area to the east which appeared on the old sheet. We hope that the new issue of cheap, accurate lithographed geological maps will henceforth replace the hand-coloured editions.

The mapping is much more detailed. The four divisions of the Upper Coal-measures are shown by distinct colours, with, in addition, brighter colours for particular beds, such as limestones and a green grit. We quite agree with the wisdom of making no distinction between Middle and Lower Coal-measures, and rejoice to see that the

shales and grits belonging to the Pendleside Series are classed with the Millstone Grit. Thus the new map indicates the absence of rocks of the true Yoredale type and the Permian series in the Stoke-on-Trent area. A dolerite dyke intrusive in Upper Coal-measures, and Bunter Pebble-beds, are mapped for the first time. The maps, both drift and solid, are accurate and full of detail, and we congratulate Mr. W. Gibson and his colleagues on the result of their work. In my copy of the solid map there is one small error of colour which does not appear on the drift edition: the lower part of the band representing Upper Coal-measure limestone south of Chesterton is coloured bright blue, instead of being the same tint as the patch a little to the north.

The Memoir (pp. 1–87, with several diagrammatic illustrations) might be included as a heading for the new section. It appears to us to be carefully and thoughtfully written, sufficient as an explanation of the map, and accurate in detail, the worst faults being probably printer's errors. Due thanks are given for all the local help received, and it has not been of small amount. Owners and engineers of mines have generously placed their plans and sections, and journals of borings, in the most unselfish way in the hands of the Survey, and local geologists have received the compliment of having many of their very radical views adopted, after a most careful review of the evidence in the field.

We note the absence of Permian and Yoredale beds from the table of strata; instead of the Permian Mr. W. Gibson gives his carefully worked out sequence of the Upper Coal-measures of North Staffordshire, and we read in the preface that "The Pottery Coal-field presents a type development of the Midland coalfields, to which the sequence in other districts can be referred."

Chapter ii, on the Millstone Grits and the beds below, by Mr. G. Barrow, F.G.S., is headed by an instructive section of the rocks across Endon. He remarks on the peculiar character of the black shales below the Crowstones and the Stanley Grit. "The dark shales contain a great number of small plant-remains, the mode of occurrence of which is suggestive of leaves falling into comparatively smooth or quiet waters. They further suggest the idea that much of the shale may be due to a process of filtration of coarser material by dense vegetation, which arrested the flow of the heavier sand particles, and at the same time supplied the great number of comparatively uninjured fragments of plants." This idea is full of suggestion, but it connotes the nearness of land, and these beds thin out very rapidly to the south and west. We note one fault, almost characteristic of Survey Memoirs, in this chapter. Mr. Barrow is quite contented with the generic names of his fossils, but we wish he had recognized the great importance of adding the species also. *Goniatites* and *Aviculopecten* convey very little accurate knowledge of horizons. The single important fact, however, comes out, that the shales between the grits and crowstones contain marine fossils as a rule. We miss, too, the list of plants found when driving through the shales between the first and third grits at Stockton

Brook Waterworks, identified by Mr. R. Kidston, and published in the Transactions of the North Staffordshire Field Club for 1889.

Chapter iii deals with the Lower and Middle Coal-measures: an artificial horizon, the Ash Coal, is taken as the base of the Middle Coal-measures. We ourselves should have felt inclined in the first place to make no subdivision, or to have placed it at the horizon of the 7 foot Banbury seam. Mr. Gibson seems doubtful of the utility of this subdivision, and it is difficult to see what good purpose it serves. He has wisely not given different colours to the two divisions on the map.

The lowest part of the coalfield, below the Winpenny Coal, is not well known, and none of the coals are now worked. The measures are about 1,200 feet thick. *Carbonicola acuta*, *Lingula Credneri*? occur in them at different horizons, as well as the marine fossils indicated. A note at the bottom of p. 19 informs us that the section marked with an asterisk is by Mr. Barrow. The asterisk has been omitted, but presumably the article on the Shaffalong Coalfield is referred to. The important seam in the Cheadle Coalfield known as the Froghall ironstone, a hæmatite which lies on or a few feet above the first grit in the neighbouring Cheadle Coal basin, has not been proved to be present either in the Shaffalong or Biddulph Valley basins.

It is pointed out that throughout the Coal-measures in North Staffordshire the measures between the coal-seams thin out rapidly to the west and thicken to the north. It is a well-known fact, and the Millstone Grit and Pendleside Series also thicken rapidly to the north and north-east, indicating the direction of the land whence the detrital matter was obtained. In connection with this subject we are informed (p. 25): "On comparing the shaft sections in this area [Biddulph] with those in the Longton district it will be noticed that there is a larger proportion of sandy material in the northern area." Naturally sand grains, being heavier, would not be transported so far as the lighter shale particles.

The nodules with marine fossils over the 7 foot Banbury seam at Lycett Colliery are strongly suggestive of the fauna and general character of the roof of the Bullion coal of Lancashire. The different character of the coals as regards cokeing (spelled 'cooking,' line 16, p. 32) is of interest, those on the east side of the coalfield not having this quality, but the same seams on the west cokeing well.

Chapter iv deals with the Upper Coal-measures, and is well worth study. Mr. Gibson has previously indicated the main features of his discoveries and views on this important series of rocks. It is not therefore necessary to give his table here in detail. It suffices to say that there are four well-marked subdivisions, which he names the Keele Series, 700 feet; Newcastle-under-Lyme Series, 300 feet; the Etruria Marls, 800 to 1,100 feet; the Blackband Series, 300 to 450 feet; of which the last is of economic importance, as it contains several valuable Blackband ironstones resting on coals which are worked together, although on p. 17, line 19, it is stated that the Upper Coal-measures contain no workable seams of coal. It is of

great interest to know that the same succession is found in the South Staffordshire, Nottinghamshire, and Denbighshire Coalfields.

A suggestive sentence on p. 37 raises the question whether the Radstock Coal-measures of the Bristol Coalfield, which Mr. Kidston believes to be still higher in the series, should come on above the Keele Series. Mr. Kidston's palæobotanical researches led him to suggest that the flora of the Upper Coal-measures of North Staffordshire are transitional between the Middle Coal-measures and the Radstock Beds. We cannot altogether accept this view as conclusive, because *Carbonicola aquilina*, a shell which does not, as far as we know, exist above the Ash Coal, is found in the plant beds of Radstock, and either the plants or the Lamellibranch therefore cannot be of such zonal importance as each specialist would suppose. Up to date, we believe, the Radstock fauna has not been found out of the Bristol area in England or Scotland.

We are informed that a larger Memoir on the North Staffordshire Coalfield is in preparation, and we await this with pleasure if the present memoir be an earnest of things to come.

In the larger memoir we hope for an account of the peculiar limestones of the Upper Coal-measures, and some discussion of their methods of deposition and source. The inconstant character of the Blackband ironstones over the whole area points to the probability that they are of secondary origin, iron having replaced calcium in a limestone, for which view there is certain positive evidence.

The Etruria Marls are largely used for brick and tile making. The green grit contained in them, composed of volcanic material, also stated to occur in other areas at the same horizon, raises an interesting question of whence it was derived, which we hope will be settled in the fuller work on the district. We are glad to note that the red colour of the Etruria Marls is shown to be original; we have always held that opinion.

To the fossils are given two pages, but we are promised better things, and the district deserves it. The long and careful work done by Mr. John Ward and others has resulted in a more accurate and detailed knowledge of the palæontology of the North Staffordshire Coalfield than of any other.

Some few specific names might have been added without difficulty, but we cannot conceive why *Carbonicola lateralis*, a synonym of *C. aquilina*, is quoted as the only species of this important genus worthy of mention.

Chapter v deals with the Triassic beds, which overlie the edges of the Pottery Coalfield with marked unconformity. The following passage shows that the author had a mental horizon not strictly limited by mere map-making (p. 52, l. 12):—"In Triassic times land had evidently obtained the upper hand. The wind-blown and false-bedded sandstones of the Bunter period are a sure index of desert conditions, while the beds of salt and gypsum of the Keuper indicate land-locked sheets of water undergoing rapid evaporation. It is difficult to account for the shingle beds, but it should be remembered that coarse gravels form no inconsiderable portion of

the deposits in the Sahara." We welcome these highly suggestive ideas on speculative problems of geology, several examples of which are scattered through the memoir.

Chapter vi treats of faults, folds, and igneous intrusions, and chapter vii of glacial deposits, which are fairly extensive. Their importance may be judged from the following passage (p. 67, l. 17): "The Trent between Abbey Villas and the railway bridge to the north flows in a shallow cutting, the surface of the water being between 390 and 400 feet above O.D., or at a higher level than the pre-glacial surface at the Hanley and Bucknall Collieries." Here the drift is 81 feet thick, making the pre-glacial surface 366 feet above O.D.

The chapter on the "Economic Resources and Applied Geology" is not the least important, but the section on the future of the Coalfield is pregnant with interest. It is gratifying to know that a rich field of coal still exists in North Staffordshire, although at great depths. The Newstead boring, the journal of which is generously made public by those for whom it was put down, shows that the uppermost seam of the Middle Coal-measures was reached at 1,946 ft. 7 in., from which it may be assumed that the Moss coal is 3,400 feet and the Cockshead 4,800 feet, and between these two seams are all the best coal-seams and many ironstones. It is therefore only a question of engineering to win them on remunerative terms.

We feel that this memoir merits unstinted praise, and it will be valued by local geologists and mining men for its accurate details and its thoughtful suggestions. W. Hind.

II.—Supplement to the Encyclopædia Britannica.

The Encyclopædia Britannica, Supplement, is a work which professes to supply the public with the very latest information on those subjects of which it treats, and naturally excites the curiosity of the man of science. And with this in view we have asked some of our younger contributors to give our readers a few ideas on the articles dealing with geological and palæontological matters in the Supplemental volumes of the Encyclopædia Britannica, six of which have been issued in the last few months.

Arachnida, by E. Ray Lankester. More like a book than an article, though one does not grumble at abundance of information. A review of the group, and of considerable importance to geologists, though there is nothing absolutely new palæontologically in the article.

Geology, by Sir Archibald Geikie. Compared with the last article is very scrappy considering the importance of the subject. Has a paragraph on zonal stratigraphy. Very curious. Still more curious is the careful reference to Professor Lapworth's work on the zones of the Silurian and Ordovician, and the absolute silence concerning the more recent work on similar lines by Wheelton Hind on the Carboniferous Limestone, by Buckman on the Inferior Oolite, and by Dr. Rowe on the White Chalk.

Ichthyology, by Albert Gunther. In this article much more attention has been paid to fossil fishes than in the article in the earlier volume. Still, in a publication intended to afford the latest information on the subject more might have been gathered from the recent work of palæichthyologists. The classification given is open to modification and does not seem in accordance with modern views.

Birds, by H. Gadow. A valuable article, which discusses the various classifications, and terminates as usual in a new classification of the author's own. Gives a summary of recent work in palæozoology, and emphasizes the futility of attempting to derive birds from the Pterosauria, as equal to that of attempting to derive them from the Dinosauria.

Cuttle-fish, by J. F. Blake. Writing on Cuttle-fish, Mr. Blake contrives to run the gamut of all the Cephalopoda, apparently with the object of explaining to the ignorant what is the exact relation of *Sepia officinalis* to the rest of the universe. Incidentally he coquettes dangerously with Steinmann's speculation that the Octopoda are the descendants of the Ammonites, a view which, if ever accepted by anyone beyond its author, has surely been disproved by the subsequent observations of Appellöf. It is also remarkable that the author of this article in the Encyclopædia Britannica should not yet have satisfied himself as to the homologies of the cuttle-bone.

Earth, Figure of. Mr. R. Radau, of Paris, writing nominally on "The Figure of the Earth," gives an account of past and future (chiefly future) expeditions to measure arcs. He prefers the ellipsoid of revolution as the spheroid of reference, but says little as to the manner or extent of difference therefrom displayed by the geoid, and says nothing about the tetrahedral theory so much boomed of late.

Coal, by H. Bauerman. Chiefly concerns mining. A sketch of the origin of coal is given, but the reader had better consult Seward's papers in "Science Progress," 1894, and his "Fossil Plants," 1898.

Alps, by T. G. Bonney. Commences with a tribute to the excellence of the article on Alps in the Encyclopædia itself. Then plunges into a brilliant survey of the whole subject. The bibliography includes Dr. Heim.

Brachiopoda, by A. E. Shipley. Mr. Shipley treats Brachiopoda chiefly from the standpoint of the anatomist, and gives a useful summary of the work of Blochmann and others. He does, however, discuss the aperture for the peduncle, and the classification based on the various modes of its closure. "What is a Brachiopod?" is an old question. Mr. Shipley is not to be caught. They are an "isolated group"; yet they "seem to belong to that class of animals which commences life as a larva with three segments"; but, lest this should be too warm a scent, he adds that "trisegmented larvæ have been found now in several of the larger groups."

EARTHQUAKES, by J. Milne. Who should write on Earthquakes if not John Milne? Right valiantly does he urge the claims of the tremulous science, giving a history of seismometry, with figures of all manner of seismometers, and showing the value of seismology in every department of human activity. Geologists will note with interest that he finds no direct connection between earthquakes worthy of the name and volcanic eruptions, but rather looks on them as a symptom of rock-folding: when a rock-bed snaps under the strain we feel the vibrating shocks, but when masses are displaced the quake undulates around the earth.

GLACIERS. There is no article on Glaciers. Perhaps the editors are awaiting the return of the "Discovery."

FENS, by J. T. Bealby. Too short, but a capital little sketch. Might have given a little more about the geological history of the area.

AMPHIBIA, by G. A. Boulenger. An up-to-date article, giving a very condensed survey of the subject, including all recent work. Excellent bibliography.

CHANNEL TUNNEL, by W. B. Dawkins. Useful sketch of the history of the work and its geological interest. Mention of Francis Brady's detailed section of the boring for coal at the same spot on the English coast, printed in 1892, would not have been out of place in this article.

ECHINODERMATA, by F. A. Bather. Considering the numbers and variety of the Echinoderms, and the enormous amount of work done on them since the rather inadequate article in the ninth edition of the Encyclopædia, we are not surprised that Dr. Bather has found it impossible within seven pages to give more than a sketch of modern views as to the morphology of the group. He has devoted himself to making clear the relations of the Echinoderma to the other phyla of the Animal Kingdom, and the supposed origins and interrelations of the various classes; but into any account of these latter he declines to be drawn, considering, no doubt, that each of them should have an article to itself.

III.—BIBLIOGRAPHY AND CATALOGUE OF THE FOSSIL VERTEBRATA OF NORTH AMERICA. By OLIVER PERRY HAY. Bull. U.S. Geol. Surv., No. 179. 8vo. (Washington, 1902.)

ANYONE who will take the trouble to cast his eye over the series of volumes which form the Bulletins of the United States Geological Survey cannot fail to be filled with admiration at the mass of digested information presented for his use, and amazement that so much bibliographic work can have been turned out in so short a period. And yet these 180 volumes (1883–1902) form only a small part of the publications of the United States Geological Survey, which is supported by the State in a manner so magnificent that it compels our envy. Not only are they models of what such publications should be, but they embrace so wide an interpretation of the word 'geology' that scarcely any subject, however remote its connection with the science, but finds a place in its

volumes. Moreover, the volumes themselves are distributed with so lavish a hand that any student can obtain them either for the asking or else for a sum so insignificant as to be afforded by the poorest.

As an instance of the range of subjects we may mention the following, all of which have formed bibliographies or books of reference of the most comprehensive and valuable nature:—

Scudder: Index to known Fossil Insects of the World.
Marcou: Catalogue of Geological Maps of America (1752–1881).
Vogdes: Bibliography of Palæozoic Crustacea.
The series of Correlation Papers.
Records of North American Geology since 1886.
The series of Gazetteers of the States. In progress.
Darton: Catalogue and Index to North American Geology, 1732–1891; continued by Weeks, 1892–1900.
Branner: Bibliography of Clays, etc.
Knowlton: Cretaceous and Tertiary Plants.
Weller: Index of North American Carboniferous Invertebrates.
Schuchert: American Fossil Brachiopoda.
Gannett: Dictionary of Altitudes in the United States.
Warman: Catalogue and Index to the Publications of the U.S. Geol. Surv.

The one before us is not the least of these invaluable books, and it is a pleasure to offer to Mr. O. P. Hay hearty and sincere thanks for a book which has long been wanted, and which will certainly be of the greatest value to British zoologists. Mr. Hay divides his book into a Bibliography (up to 1900); a tabular Key to the catalogue; a Catalogue (of the genera and species); Addenda et Corrigenda; Index. The whole book runs to 868 pages. The synonymy is compressed into a minimum of space, by an arrangement of quotation by which the several papers are referred to by year and page only, the reader having to refer to the Bibliography for the full quotation. This, though a loss of time to the user, seems inevitable now that the subjects have grown to such vast dimensions. The Index is arranged under trivial names, each followed by its generic variant, and thus any specific name can be found without trouble.

To criticize such a work as Mr. Hay's would not be possible without great trouble; use only can show whether his work is accurate. However that may be, we have to thank him for his labours, labours rarely fully appreciated by those who find in such books almost half of their own work done for them. C. D. S.

IV.—Harlyn Bay and the Discoveries of its Prehistoric Remains. By R. Ashington Bullen, B.A., F.L.S., F.G.S., etc. Second Edition, revised and greatly enlarged. 8vo; 96 pages, with 18 plates and 9 text-figures. (London: Sonnenschein & Co., 1902. Price 1s.)

THE truthful records of any people lead us to consider the land in which they dwelt, and especially its surface accumulations, retaining evidences of early human occupation. These may be

ornaments, utensils, tools, or weapons; relics of the life-abodes or skeletal remains. Thus archæology and geology have met in the study of very many interesting exposures of archaic remains; and now attention is directed to Harlyn Bay, near Padstow, in Cornwall. Here a prehistoric grave-ground and a recognizable hut near by form an interesting picture of long past times, framed on one side with the great Palæozoic crags of the Bay, on the other hand passing into the wide Atlantic with its mysteries of sunken lands and lost Atlantis.

The details have been preserved by the thick coating of shore-sand derived in ages past, partly from broken sea-shells and partly by sea and wind from rocks and strata no longer visible.

The neighbouring country is characterized by the tumuli and flint weapons of people of the later Stone-age. But on the shore of the Bay, in making foundations for a new house, there were found beneath 15 feet of sand at least a hundred slab-made cists or stone graves, with bones of the ancient people, accompanied by many flakes of the hardest slate of the vicinity. These bits of slate had been deftly trimmed into pointed and sharp-edged knives, besides awls, scrapers, hammers, etc. Some are shown in plates iv, v, and vi. The use of slate for tools and utensils is illustrated with reference to other observers abroad and at home. Some small flint flakes and tools from near Harlyn are shown in plate vii.

The slabs of slate and flagstones largely used for the sides, ends, and covers of the cists were obtained from the rocks near by (known as 'Devonian' in systematic geology). In some cases blocks of stone had evidently been dropped directly on the head of the dead or dying persons laid in the graves. In some graves the whole skeleton had been intentionally flattened by the fall of the upper slab. Mr. Bullen has carefully quoted the descriptions given by some authors of such maltreatment of the dead or dying occupants of new graves; also as to the occasional custom of separated limbs being arranged in burial; and indeed, further, he has to allude to the sacrificial imbedding of a living victim, for he has noticed evidently a more or less analogous case under some of the old stonework. Thus there are here subjects of study for the archæologist in the graves, and for the geologist in the surroundings. This little book, with its numerous plates and figures, abundantly proves this; and the author's particularly careful collateral allusions to analogous customs among various ancient and archaic people give much interest and instruction to the reader.

REPORTS AND PROCEEDINGS.

Royal Society of New South Wales.

(From the Abstract of Proceedings, September 3rd, 1902.)

Professor Warren, M. Inst. C.E., etc., President, in the Chair.

Among others, the following paper was read: "Meteoric Dusts, New South Wales," by Professor Liversidge, M.A., LL.D., F.R.S.

The term meteoric dust is used because it is commonly applied to the materials forming the subject of this paper; it is not intended to state that the dusts are necessarily of cosmic or extra-terrestrial origin. The specimens described and exhibited were from Moruya (fell on Dec. 15th, 1880), from Uralla (fell on Dec. 14th, 1882), from near Broken Hill (fell 1896), from Menindie (fell June 17th, 1899), and Pambula (fell Oct. 5th, 1899). Dust from the roof-beams and mud from a covered cistern at the University and from the roof of the Observatory, Sydney, all three were collected in 1882. All the dusts are of a reddish colour except those from the University and Observatory, which are grey. The red dusts are mainly silicious and argillaceous, and look as if they had come from dried-up water-holes; they contain a variety of organic and mineral matters such as might be expected from such a source, and in addition magnetite and metallic iron; the latter contains cobalt and nickel, which seems to indicate that the dusts contain some cosmic or extra-terrestrial materials, part of which may have settled down and become mingled with the undoubted superficial terrestrial deposits and part may have been derived directly from the atmosphere. The University and Observatory dusts also yielded magnetite and metallic iron containing cobalt and nickel, and the University dust yielded particles of gold; the Observatory dust has yet to be tested. The Moruya, Menindie, and Barrier red dusts yielded particles of gold; the others have yet to be examined. Fuller information is given in the paper as to the constituents and chemical composition of the dusts, and analyses of volcanic and other dusts for comparison.

Professor Liversidge also exhibited under the microscope particles of a malleable yellow metal, which have all the appearance of gold, obtained from certain Australian and European meteorites (siderolites). The presence of gold in meteorites bears upon the presence of gold in 'meteoric' dusts, and it is also of great interest in connection with the presence of gold upon the earth and in sea-water, inasmuch as meteorites and the dust of meteorites are constantly falling upon the earth to the extent of probably many million tons a year. Further information upon the question of the presence of gold in meteorites will be given shortly in a subsequent paper.

CORRESPONDENCE.

HYDROTHERMAL METAMORPHISM.

Sir,—I crave a few words of explanation of my paper on Hydrothermal Metamorphism noticed in your current number. The ulterior object of the paper was to elicit a discussion on the singular fact that in the Devon schists albite containing fluid inclusions is intimately associated with chlorite and other water-bearing minerals; and this in rocks which show no sign of any high temperature, far less of fusion. So far as I am aware, albite has only been produced artificially in the crucible at a high temperature. After my little paper was written I found to my

dismay that it would appear to intrude on the subject of the President's Address, and on hearing the address I found that the President actually discussed the fusion temperature of albite from one extreme, whereas I had hoped to coax a discussion on the other extreme. Thus, instead of being able to ask the opinion of the section, I was obliged with all emphasis to warn the section not to allow my paper to be an excuse for discussing the President's views, and so transgress the inviolable custom of the British Association, not to attack a chairman when he is not free to defend himself. My paper being sent in too late for me to supply an abstract, the Recorder of Section C most kindly wrote the excellent epitome you have published, and therein stereotyped an undoubted ambiguity which I subsequently corrected in reading. Of course, hornblende does not always contain water, as might be inferred from my manuscript; but certain varieties are said to do so. But in the event of the hornblende being rejected, the chlorite, epidote, zoisite, and the fluid inclusions in the albite, are sufficient to prove my point.

A. R. Hunt.

Foxworthy, Moretonhampstead.

'SONOROUS' SAND.

Sir,—In September last I paid a visit to Tenby, and while there made a point of seeing the notable junction between the Old Red and Carboniferous series of rocks. The section is met with a few miles to the west of Tenby, in a small bay called Skrinkle Haven. I was doubly repaid for the effort of getting to this not very accessible spot by seeing a most interesting geological section, and finding musical notes emitted from some of the sand traversed while examining the junction.

I had never met with the phenomenon before, and, being preoccupied, at first attributed the sounds to a knocking together of articles on my person; but, giving my attention to it, found the sounds arose from my feet at each step, as my boots sank into the sand. The notes were clear and metallic, and were emitted only from the dry, loose sand above the range of the tide. I did not test its 'musical' property in any other way than walking in it, but found an increase in the sound on thrusting the heel deeper into the sand.

In *Nature*, vol. xxxix, there are references made to investigations and explanations in regard to these sounds. Dr. Julian and Professor Bolton attribute them to "a film of condensed air round each grain of sand, which acts as an elastic cushion, and enables the sand to vibrate when disturbed," while Mr. C. Carus Wilson considers the sound to be caused by friction, "the cumulative effect of numerous vibrating particles that becomes audible."

In accordance with Mr. Wilson's theory, the grains in the patch of sand which emitted the sounds "were rounded, polished, and free from fine fragments; they must have had sufficient amount of 'play' to enable them to slide one against the other; the grains were perfectly clean, and possessed a certain degree of uniformity, within a certain range of size" (vide *Nature*, vol. xliv, p. 322).

A number of places where such sand is met with is given by these writers and others, but as no mention, as far as I am aware, is made of Skrinkle Haven, I thought it might be of sufficient interest to justify this note. HARFORD J. LOWE, F.G.S.

TORQUAY.

SOUTH AFRICAN PETROGRAPHY.

SIR,—In my paper on the above subject in the August number I should like to point out two errors. Fig. 4 represents the diorite described immediately above it, and not, as stated, the granite referred to on p. 364. The other error, for which I am myself responsible, is in a reference to the melilite-bearing rock of the Spiegel River in Cape Colony (p. 366). This was discovered by Messrs. Rogers & Schwarz, of the Cape Geological Commission, and described by them in the report of that body for 1898, p. 62. Professor Cohen's description referred to is of a Transvaal rock of a similar character, and I cannot now account for having confused it with the other. My delay in correcting this slip is due to absence up country, during which I received no papers. F. P. MENNELL.

RHODESIA MUSEUM, BULAWAYO, 1902.

THE CRUMLIN METEORITE.

SIR,—In your issue for November, p. 521, you remark in regard to the meteoric stone that fell at Crumlin on September 13th, that "no one [in Ireland] thought it worth while to investigate what appeared to be a hoax." May I state, as I have already done in the *Irish Times*, that the first newspaper notice of the event appeared in the *Northern Whig* for Sept. 17th, when I was crossing to Scotland. This contained so clear an account that I never suspected the fall to be other than genuine, and at once commenced negotiations on behalf of the Museum in Dublin. Mr. Walker, the owner of the stone, although at the time unwell, replied promptly; but I was by then travelling in Scotland, and his letter was forwarded to me to an incorrect address. Consequently, I received it only on October 29th, and had heard long before that the stone had been, very naturally, secured for the British Museum. GRENVILLE A. J. COLE.

DUBLIN, *Nov. 3rd*, 1902.

FOSSILS OF THE OXFORD IRON-SANDS.

SIR,—As the fresh-water fossils of the Oxford Iron-sands are now so difficult to obtain, it is worth noting that during a traverse of the Lower Cretaceous outcrop which I made in June last I chanced to find a place where these fossils can be obtained in abundance, though not from rock actually *in situ*. The locality is Combe Wood, about half a mile south of Wheatley Station and five miles E.S.E. of Oxford. A low stone wall on the western side of the high road which flanks this wood on the west is in places built of thin, flaggy iron-grit crowded with the casts of *Unio*, *Cyrena*, *Paludina*, etc. The stone for this old wall must have been obtained in the immediate vicinity, probably from a small pit now

overgrown and concealed in the adjacent woodland. I found afterwards that most of the Iron-sand fossils preserved in the Geological Survey Museum at Jermyn Street, collected many years ago, are labelled "Combe Wood," and are in all respects like those which I obtained from the wall; they were probably got when the quarry was open. This flaggy iron-grit may possibly form part of the supposed Purbeck deposit of Combe Wood described by Fitton and mentioned by Professor Phillips, though more probably it has been obtained from the sands just above that horizon.

I was able to devote only a very short time to the examination of the material, but noticed that the fauna, though rich in individuals, was scanty in species. A more thorough investigation is, however, highly desirable, especially as the relation of this fresh-water fauna to the marine Lower Greensand stands in great need of elucidation.

G. W. Lamplugh.

Bridlington Quay.
November 4th, 1902.

'CALCRETE.'

Sir,—"Murder will out," whether of person or language, and the appearance in the October number of the *Irish Naturalist* of a new word for which I am responsible makes requisite an open confession. The word is 'calcrete,' applied in this instance by a friend who has become accustomed to the term through our conversation, and has trustfully used it as a 'good' word in describing the shelly drift-gravels near Dublin. The indiscretion will be repeated, by my colleagues as well as myself, in the forthcoming new edition of the Geological Survey Memoir on the neighbourhood of Dublin, and preliminary explanation and definition seems therefore desirable. In the drifts around Dublin, as in most places where in like manner limestone-débris enters largely into the composition of the superficial deposits, the sand-and-gravel beds are often cemented sporadically into hard masses by solution and redeposition of lime through the agency of infiltrating waters. In order to indicate this condition on the field-maps a terse expression was sought to replace such long and awkward circumlocutions as 'conglomerated gravel,' 'calcareous concreted gravel,' etc., and for this purpose the abbreviation 'calcrete' was invented and found adequate. Other workers under similar conditions may find the word equally serviceable, and to them I therefore recommend it.

Moreover, I have the hardihood to suggest that the term might be complemented by equivalents,—'silcrete,' for sporadic masses in loose material of the 'greywether' type, indurated by a siliceous cement; and 'ferricrete' when the binding substance is an iron-oxide. I will grant that these terms are etymologically somewhat imperfect, but the inconvenience of an additional syllable would be a more weighty objection where expressive brevity is of prime consequence.

G. W. Lamplugh.

Bridlington Quay.
November 4th, 1902.

RADIOLARIAN CHERTS IN THE CULM.

SIR,—I wish to call attention to a Review of the Geological Survey Memoir on "The Geology of the Country around Exeter" which appeared in your November number, pp. 524–525.

Probably through a printer's error the title (Explanation of Sheet 325) has been rendered "(Explanation of Sheet 25)."

Lower Culm-measures are said to "embrace a large extent of the Exeter area" dealt with in this Memoir. As a matter of fact the Lower Culm rocks occupy a very small area on the south-western margin of the map; and, as far as I know, they have not been searched for Radiolaria by my friend Mr. Fox, although he records their discovery in many places in the map to the south (Sheet 339).

As regards being up-to-date, the literature of the Culm-measures would have shown the writer the groundlessness of the charge that I have not acknowledged my friend Mr. Fox's discoveries.[1]

METHLEIGH, ST. AUSTELL, CORNWALL. W. A. E. USSHER.
November 23rd, 1902.

OBITUARY.

WILLIAM GUNN, F.G.S.

BORN SEPTEMBER 27, 1837. DIED OCTOBER 24, 1902.

MR. WILLIAM GUNN joined the staff of the Geological Survey in 1867 under Murchison, and was occupied for many years chiefly in the survey of the Carboniferous rocks in West Yorkshire, Durham, and Northumberland. In 1884 he was promoted to the rank of Geologist, and was transferred to Scotland, taking up work in Bute, and proceeding subsequently to the North-West Highlands. In later years he was engaged in the Survey of the Isle of Arran, and among other interesting discoveries he found evidence of a volcanic vent of Tertiary age which enclosed fragments of Rhætic and other Secondary strata, not previously recognized in the island. Mr. Gunn was author of memoirs published by the Geological Survey on Belford, Holy Island, and the Farne Islands, on the coast south of Berwick-on-Tweed, on Norham and Tweedmouth, and he was joint author of memoirs on Wooler and Coldstream, on Ingleborough, and on Corval in Argyllshire.

His other contributions to geology related for the most part to the rocks which he had studied in the course of his official work. He thus communicated occasional papers to the Transactions of the Edinburgh Geological Society, the Berwickshire Naturalists' Club, the Glasgow Geological Society, the Geological Society of London, and the GEOLOGICAL MAGAZINE.

All his work was of a thorough and most painstaking character. He enjoyed the active outdoor life of a geologist, and continued to carry on field-work until near the close of his life, when, having attained his 65th year, the age-limit obliged him to retire from the service. Only last year he was promoted to the rank of District Geologist.

[1] [The Reviewer doubtless referred only to Memoir on Sheet No. 325, in which the name does not seem to occur.—EDIT. GEOL. MAG.]

INDEX.

ACA

ACANTHOPLEURELLA Grindrodi, Groom, gen. et sp. nov., 70.
Acrothyra and *Hyolithes*, 523.
Address to Section C by General McMahon, 458.
Age of Stone Implements, 97.
Aids to Practical Geology, 380.
Alpine Valleys in relation to Glaciers, 382.
Alps, Moraines and Mud-streams in the, 8.
Alveolina - Limestone and Nummulitic Limestones from Egypt, 62, 106.
American Museum of Natural History, 144.
Ami, H. M., Cambrian Age of the *Dictyonema* Slates of Nova Scotia, 218; On the Great Saint-Lawrence-Champlain - Appalachian Faults of America, 425.
Ammonite Nomenclature, Emendations of, 380.
Ammonites calcar, Zieten, Note on, 47.
Andrews, C. W., Extinct Vertebrates from Egypt, 291; The Pliocene Vertebrate Fauna from Wadi-Natrun, Egypt, 433.
Annual General Meeting of Geological Society, 181.
Antiquity of Man, 16.
Arachnida, *Eophrynus* and Allied Carboniferous forms, 439, 487.
Arachnids, Carboniferous, 522.
Arber, E. A. N., *Glossopteris* Flora of Australia, 173; Distribution of the *Glossopteris* Flora, 346; Fossil Flora of the Cumberland Coalfields, 519.
Arenig Rocks, Aberdaron, Carnarvonshire, 118.
Atlantis Problem, 455.
Avebury, Lord, The Scenery of England and the Causes to which it is due, 232.

BACKWARD Step in Palæontology, 561.
Bacon, Huxley, Darwin, and Lyell, A Vindication of, 265.
Bagshot Beds, Combe Pyne, near Lyme Regis, 515.

BUR

Bairdia Beadnelli, Chapman, sp. nov., 66.
Bairdia minuta, Chapman, sp. nov., 66.
Bala Lake and River System, North Wales, 384.
Baltic, Uppermost Chalk of, 287.
Barbados, Recent Fall of Volcanic Ash in, 330.
Barbados, The Geology of, 550.
Basalt of the Moabite Stone, 493.
Bather, F. A., Appointment as Assistant-Keeper, 380.
Beecher, C. E., The Ventral Integument of Trilobites, 152; Revision of Phyllocarida from Chemung and Waverly Groups, 327.
Belfast, Geology of the Country around, 516.
Belfast District, Post-Glacial Deposits of, 517.
Bertrand & Zurcher, Geological Studies on the Isthmus of Panama, 419.
Blake, J. F., Inlier among the Jurassics of Sutherland, 281; Sedimentary Deposits, 473.
Bolivian Fossils and Rocks, 40.
Bonin Islands, On the, 296.
Bonney, T. G., Moraines and Mud-streams in the Alps, 8; Relations of Breccias to the Physical Geography, 141; A Sodalite Syenite from Ice River Valley, Canadian Rockies, 199; Alpine Valleys in relation to Glaciers, 382; Basalt of the Moabite Stone, 493; The Canadian Rockies, 544.
Brachypyge celtica, Pocock, sp. nov., 488.
Bredon Hill, Inferior Oolite of, 513.
Brögger, W. C., Glacial Changes in Christiania, 317.
Buckland and his Detractors, and Kent's Cavern, 114.
Buckman, S. S., River Development, 366, 527; The Term Hemera, 554.
Bullen, R. A., Prehistoric Remains at Harlyn Bay, 570.
Bunter Pebble-Bed of the West of England, 327.
Burckhardt, C., The Geology of the Argentino-Chilian Cordilleras, 277.

CAL

CALAMITES, Primitive Type of Structure in, 73.
'Calcrete,' 575.
Callaway, C., The Zigzag Course of the Cheddar Gorge, 67; The Crystalline Limestones of Ceylon, 284; Plutonic Complex of Central Anglesey, 382; Cause of River Curves, 450.
Cambrian Age of *Dictyonema* Slates, Nova Scotia, 218.
Cambrian Fossils from Mount Stephen, British Columbia, 502, 530.
Cambrian of Cape Breton, with Descriptions of New Species, 172.
Cambrian Ostracoda from N.E. America, 401.
Campyloprion, a new form of *Edestus*-like Dentition, 148.
Campyloprion, Figures of, 332.
Campyloprion annectans, Eastman, gen. et sp. nov., 151.
Canadian Rockies, 544.
Carboniferous Fish Fauna from Victoria, Australia, 471.
Carboniferous, Permian, and Triassic Rocks in Isle of Man, 331.
Carnarvonshire, Arenig Rocks, Aberdaron, 118.
Cenomanian Overlap, 495.
Ceylon, The Scenery of, 476.
Chalk Foraminifera, 562.
Chalk, Upper, of Lincolnshire, 404.
Chapman, F., *Alveolina* and Nummulitic Limestones from Egypt, 62; Foraminifera, a Study of the Protozoa, 175.
Cheddar Gorge, Zigzag Course of, 67.
Chitral, Fossil Beds and Rocks at, 3.
Clark, R., Silurian Fossils of N.E. Ireland, 497.
Coal, Royal Commission on, 96.
Coal and Petroleum in European Turkey, 79.
Cole, G. A. J., Aids to Practical Geology, 380; Geological Structure of Ireland, 456; Geology around Belfast, 516; The Crumlin Meteorite, 574.
Coleman, A. P., Changes of Level and Interglacial Periods, 59, 106.
Columbella, The Genus, 477.
Concretions in the Coal-measures, 44.
Conditions under which Manganese Dioxide has been deposited, 558.
Conflict of Truth, 418.
Coomáraswámy, A. K., The Limestones of Ceylon, 190, 372; Radiolaria in Gondwána Beds, 305; The Point-de-Galle Group (Ceylon): Wollastonite-Scapolite-Gneisses, 425; Scenery of Ceylon, 475.
Correlation of the Palæozoic Rocks of South Africa, 164, 210.
Creechbarrow in Purbeck, 242.

EKH

Crick, G. C., *Ammonites calcar*, Zieten, 47; The Genus *Tmaegoceras*, Hyatt, 127; On *Nautilus robustus*, 342.
Crumlin Meteorite, 574.
Crystalline Limestones of Ceylon, 190, 284, 372, 375.
Cumberland Coalfields, Marine Flora of, 519.
Cythere farafrensis, Chapman, sp. nov., 66.

DAKYNS, J. R., Effects of Lightning near Snowdon, 142.
Darjíling Gneiss, Petrographical Characters of, 30.
Dartmoor, Past and Present of a bit of, 397.
Davison, C., The Carlisle Earthquake of July 9th and 11th, 1901, 283; An Inverness Earthquake of September 18th, 1901, 383.
Dawkins, W. Boyd, The Red Sandstone Rocks of Peel (Isle of Man), 331; Rocks under the Glacial Drift, Isle of Man, 331.
Dawson, G. M., Geological Survey of Canada, Annual Report, 235.
Dean Buckland and McEnery, 85.
Dictyonema Slates from Nova Scotia, 218.
Distribution of the *Glossopteris* Flora, 346.
Ditroite from Canadian Rocky Mountains, 199.
Donald, J., On Proterozoic Gasteropoda, 192.
Drepanaspis Gemündenensis, Schlüter, 289.
Dwerryhouse, A. R., Glaciation of Teesdale, Weardale, and Tyne Valley, etc., 84.

EARTHQUAKE Investigation, 514.
Earthquakes at Carlisle, July, 1901, 283; at Inverness, September, 1901, 283; in Greece, 380.
Eastman, C. R., *Campyloprion*, a new form of *Edestus*-like Dentition of Sharks, 148; Figures of *Campyloprion*, Plate VIII, 332; On the Genus *Peripristis*, 388.
Echinocaris Sloliensis, Partridge, sp. nov., 307.
Echinocaris Whidbornei, Jones & Woodward, 307.
Egypt, Nummulitic Limestones from, 62, 106.
Ekholm, Dr. Nils, Meteorology of Pleistocene Epoch, 43.

ELA

Elater Wisniowskii (Lomnicki), 40.
Elsden & Greenwell, Road Construction, etc., 76.
Encyclopædia Britannica, Supplement to, 567.
England, Scenery of, and Causes to which it is due, 232.
English Rivers, Mr. A. Strahan on some, 334.
English, T., Coal and Petroleum Deposits in Turkey, 79.
Eophrynus and Allied Carboniferous Arachnida, 437, 487.
Eosiren libyca, Andrews, gen. et sp. nov., 293.
Erosion, Examples of Marine and Sub-aerial, 406.
Exeter, Geology of the Country around, 524.
Extinct Vertebrates from Egypt, 291.

FLETCHER, L., A British Meteorite, 521.
Flett & Geikie, The Granite of Tulloch Burn, Ayrshire, 38.
Flints, Haldon Hill, *Marsupites* in, 449.
Footprints from the Keuper in S. Staffordshire, 215.
Foraminifera, 418.
Foraminifera: an Introduction to the Protozoa, 175.
Fossil Fishes in the British Museum, Catalogue of, 133.
Fossil Vertebrata of North America, 569.
Fossil Water in Sedimentary Strata, 559.
Fossiliferous Silurian Beds, Clogher Head District, 139.
Fossils from the Cretaceous Strata of the Salt Range, 471.
Fossils from the Hindu Khoosh, 3, 50.
Fossils from the Silurian Area of N.E. Ireland, 497.
Fossils in the Oxford Iron-sands, 574.
Friedberg, W., Chalk Foraminifera, 562.

GAPS in the Lias, 189.
Gardner & Reynolds, Fossiliferous Silurian Beds, etc., of Clogher Head, 139.
Garwood, E. J., The Origin of some 'Hanging Valleys' in the Alps and Himalayas, 383.
Gaudry, Prof. A., Presentation of a Gold Medal to, 240.
Geikie & Flett, The Granite of Tulloch Burn, Ayrshire, 38.
Geological Age of the Ogasawara Group, 296.

GUN

Geological and Physical Development of Barbados, 82; of Dominica, etc., 80.
Geological Congress, The Pyrenees at, 349.
Geological Society of London, 42, 79, 139, 181, 281, 326, 381, 427.
Geological Society of London, Lake *v.* Strahan, 384.
Geological Society of London, Limits of Legitimate Speculation at the, 333.
Geological Society, The German, 417.
Geological Structure of Ireland, 456.
Geological Studies on the Isthmus of Panama, 419.
Geological Survey of Canada, 235, 417.
Geological Survey of England and Wales, 524, 563.
Geological Survey of England and Wales and the White Chalk, 478.
Geological Survey of Maryland, 417.
Geological Survey of United Kingdom, 40, 144.
Geology, A Text-book of, 274.
Geology of Perim Island, 206.
Geology of the Argentino-Chilian Cordilleras, 277.
Geology of the Country around Southampton, 524.
Giant Beaver from the Thames Valley, 385.
Gibson, Walcot, Correlation of the Palæozoic Rocks of South Africa, 163, 210; Geology of the Country around Stoke-upon-Trent, 563.
Glacial Changes in Christiania, 317.
Glaciation, Teesdale, Weardale, and Tyne Valley, 84.
Glacier-Lakes in the Cleveland Hills, 83.
Glamorganshire, Trilobite from the Culm of, 481.
Glossopteris Flora, Distribution of, 346.
Glossopteris Flora of Australia, 173.
Gold Fields of Wainad in Southern India, 132.
Gondwâna Beds near Madras, Radiolaria in, 305.
Goodchild, J. G., Scottish Ores of Copper in their Geological Relations, 74.
Granite of Tulloch Burn, Ayrshire, 38.
Greenly, E., Origin and Associations of the Jaspers of S.E. Anglesey, 326.
Greenwell & Elsden, Roads, their Construction and Maintenance, 76.
Griffithides Barkei, H. Woodw., sp. nov., 484.
Groom, T. T., New Genus belonging to the Leperditiadæ from the Cambrian of Malvern, 45; Sequence of the Cambrian and Associated Beds of the Malvern Hills, 46; New Trilobite from the *Dictyonema*-shales of Malvern, 70.
Gunn, W., Obituary of, 576.

HAE

HAECKEL'S Riddle of the Universe, 78.
'Hanging Valleys' in the Alps, Origin of some, 383.
Harker, A., Ice-Erosion in the Cuillin Hills, Skye, 35.
Harrison (J. B.) & Jukes-Browne, Geology of Barbados, 550.
Harrison, W. J., A Bibliography of Stonehenge and Avebury, 275.
Hatch & Hayden, Goldfields of Wainad, Southern India, 132.
Hay, O. P., Catalogue of the Fossil Vertebrata of N. America, 569.
Hemera, The Term, 554.
Hemming, A., The Uppermost Chalk of the Baltic, 287.
Hertfordshire, Geology of, 568.
Hill, E., The Matrix of the Suffolk Chalky Boulder-clay, 141.
Hill, W., The Upper Chalk of Lincolnshire, 404.
Hindu Khoosh, Fossils from the, 3, 50.
Hippopotamus Madagascariensis, Guldb., 193.
History of Geology and Palæontology to the End of the Nineteenth Century, 174.
History of Graphite, 180.
Holocene Deposit at Castle Cary, 87.
Howorth, H. H., Origin and Progress of the Modern Theory of the Antiquity of Man, 16.
Hudleston, W. H., Creechbarrow in Purbeck, 241.
Hudleston & McMahon, Fossils from the Hindu Khoosh, 3, 49.
Hull, E., Sub-Oceanic River Valleys, 286.
Hull Museum, 562.
Hunt, A. R., On Kent's Cavern with reference to Buckland and his Detractors, 114; Vindication of Bacon, Huxley, Darwin, and Lyell, 265; On the occurrence of *Scalaria communis* in the Raised Beach on Thatcher Rock, 285; Littoral Drift, 428; Hydrothermal Metamorphism of the Schists of South Devon, 474; Hydrothermal Metamorphism, 572.
Hyolithes gracilis and related forms, 524.

ICE-EROSION in the Cuillin Hills, Skye, 35.
Ichthyosaurus thyreospondylus from the Kimeridge Clay, Specton, 427.
Igneous Complex of Magnet Cove, Arkansas, 177.
Inlier among the Jurassic Rocks of Sutherland, 281.
Interglacial Periods, Changes of Level, 59.
International Geological Congress, 378.

LYM

Inter-Permian Movement of the Pennine Faults, 510.
Ireland, Geological Structure of, 456.
Ireland, List of Minerals occurring in, 500.

JASPERS of S.E. Anglesey, Origin and Associations of, 326.
Joly, J., The Viscous Fusion of Rock-forming Minerals, 475.
Jones, T. R., Cambrian Ostracoda from N.E. America, 401.
Jukes-Browne, A. J., Student's Handbook of Stratigraphical Geology, 279; A Deep Boring at Lyme Regis, 282; *Marsupites* in the Flints of Haldon Hill, 449; The Cenomanian Overlap, 495; Geology of Barbados, 550.
Jurassic Strata on South Wales Line between Filton and Wootton Bassett, 426.

KENDALL, P. F., A System of Glacier-Lakes in the Cleveland Hills, 83; Brockrams of the Vale of Eden, 510.
Kennard & Woodward, The Holocene Deposit at Castle Cary, 87.
Kent's Cavern with reference to Buckland and his Detractors, 114.
Kesh Caves, County Sligo, Exploration of, 505.
Keuper of S. Staffordshire, Footprints from, 215.
Kilroe & McHenry, Silurian and Ordovician Rocks of N.W. Ireland, 172.
King, The Hon. Clarence, Obituary of, 143.

LAKE, P., The Limits of Legitimate Speculation at the Geological Society, 333; Rivers of Wales, 428.
Lakes of Snowdonia, 430, 527.
Lamplugh, G. W., Fossils in the Oxford Iron-sands, 574; 'Calcrete,' 575.
Lency, Frank, List of Figured Types of Fossils in the Norwich Museum, 166, 220.
Leperditiadæ, On a new Genus of the, 45.
Lichas, Note on the Genus, 42.
Lincolnshire, Note on the Upper Chalk of, 404.
Littoral Drift, 428.
Lowe, H. J., The Past and Present of a bit of Dartmoor, 397; 'Sonorous' Sand, 573.
Lower Cretaceous of North Germany, 561.
Lyme Regis, On a Deep Boring at, 282.

MACKIE, W., Manganese Dioxide in Sedimentary Rocks, 558; So-called Fossil Water of Sedimentary Strata, 559.
Major, C. J. Forsyth, On *Hippopotamus Madagascariensis* from Sirabé, Madagascar, 193; Pliocene Voles, 522.
Making of Quartz Schist, 259.
Malvern Hills, Cambrian and Associated Rocks of the, 46.
Malvern Hills, New Trilobite from the, 70.
Manchester Museum, 563.
Mansel-Pleydell, J. C., Obituary of, 335.
Marine and Subaerial Erosion, 406.
Marine Fauna of the Boulder-clay, 518.
Marine Shells, 479.
Marr, J. E., Lakes of Snowdonia, 430, 527.
Marsupites in Flint on Haldon Hill, 449.
Matley, A., The Arenig Rocks near Aberdaron, 118.
Matrix of the Suffolk Chalky Boulder-clay, 141.
Matthew, G. F., Fossils from the Cambrian of Cape Breton, 172; A Backward Step in Palæontology, 561.
McHenry & Kilroe, Silurian and Ordovician Rocks of N.W. Ireland, 172.
McMahon, C. A., Address to the Geological Section at Belfast, 458.
McMahon & Hudleston, Fossils from the Hindu Khoosh, 3.
Mennell, F. P., The Wood's Point Dyke, Victoria (Australia), 284, 392; Contributions to South African Petrography, 354, 574.
Meteorite, A British, 521.
Milne, J., Earthquake Investigations, 514.
Mineral Analysis of Rocks, A Process for the, 140.
Minerals, A Preliminary List of, occurring in Ireland, 500.
Moabite Stone, The Basalt of the, 493.
Mæritherium gracile, Andrews, sp. nov., 292.
Monckton, H. W., On Marine and Subaerial Erosion, 406; Valleys of the Hardanger Fjord, 476; England during the Pliocene and Recent Times, 520.
Monzoni and Upper Fassa, 309, 384.
Moraines and Mud-streams in the Alps, 8.

NATURAL Science Records, 379.
Nautilus robustus, Foord & Crick, 342.
Newton, E. T., Sub-Fossil Yew-Wood, 48; The Great Beaver from the Thames Valley, 385.
Newton, R. B., List of Say's Types of Maryland Mollusca, 303.
Nolan, Joseph, Obituary of, 288.
Norwich Museum, Type and Figured Specimens in the, 166, 220.

OBITUARIES: Samuel Rowles Pattison, 48; Ralph Tate, 87; James Shipman, 95; Clarence King, 143; Frederick Smithe, 143; Otto Torell, 235; Joseph Nolan, 288; William Henry Penning, 335; John Clavell Mansel-Pleydell, 335; Ferdinand von Roemer, 412; Philip J. Rufford, 430; William Gunn, 576.
Ogilvie-Gordon, M. M., Translation of Von Zittel's History of Geology and Palæontology, 174; Monzoni and Upper Fassa, 309, 384.
Oligocene and Miocene Deposits of the Great Plains, 562.
Oligocene of Western Europe and Southern United States, 477.
Origin and Progress of the Modern Theory of the Antiquity of Man, 16.
Origin of Crystalline Limestones of Ceylon, 375.
Ostracoda from the Cambrian of N.E. America, 401.
Ostracoda of the Basal Cambrian Rocks of Cape Breton, 418.
Outlier of the Plutonic Complex of Central Anglesey, 382.
Overlap, The Cenomanian, 495.
Overthrusts and other Disturbances in the Braysdown Colliery, 329.

PACE, S., The Genus *Columbella*, 477.
Papers read before the British Association in Section C, etc., 468.
Parkinson, J., Petrographical Characters of the Darjíling Gneiss, 30; The Making of a Quartz Schist, 259.
Partridge, E. M., On *Echinocaris Whidbornei*, 307.
Patagonian Tertiary Mollusca, 526.
Pattison, S. R., Obituary of, 48.
Pecten maximus and *venerupis*, sp., at Hope's Nose, 285.
Penning, W. H., Obituary of, 335.
Perim Island, Notes on the Geology of, 206.
Perim Island and its Relation to the Area of the Red Sea, 132.
Peripristis, On the Genus, 388.
Petrographical Characters of the Darjíling Gneiss, 30.
Petrography, Contributions to South African, 356.

PHI

Phillipsia spatulata, H. Woodw., sp. nov., 482.
Phosphatic Nodules in the Upper Carboniferous Limestone of Yorkshire, 39.
Photo-micrography, 523.
Phyllocarida from Pennsylvania, Revision of the, 327.
Physical Geography, A Fragment of, 397.
Pliocene Changes in England, 520.
Pliocene Glacio-Fluviatile Conglomerates, Subalpine France and Switzerland, 328.
Pliocene Vertebrate Fauna from Wadi-Natrun, Egypt, 433.
Pocock, R. I., *Eophrynus* and Allied Carboniferous Arachnida, 439, 487.
Polish Geology, 478.
Praeger, R. L., Post-Glacial Deposits of the Belfast District, 517.
Prehistoric Remains at Harlyn Bay, 570.
Preller, C. S. Du Riche, On Pliocene Glacio-Fluviatile Conglomerates in Subalpine France and Switzerland, 328.
Presentation of a Gold Medal to Prof. A. Gaudry, 240.
Proetus Coddonensis, H. Woodw., sp. nov., 482.
Proterozoic Gasteropoda, 192.
Purbeck, Creechbarrow in the Isle of, 242.
Pyrenean Volcanoes, 417.
Pyrenees, at the last Geological Congress, 349.

QUARTZ Schist, On the Making of a, 259.

RADIOLARIA in Gondwána Beds near Madras, 305.
Radiolarian Chert in the Culm, 576.
Railway Cuttings in Suffolk, 129.
Raisin, C., Perim Island, 132; Notes on the Geology of Perim Island, 206.
Record of the Royal Society, 144.
Red Sandstone Rocks of Peel (Isle of Man), 331.
Reed, F. R. Cowper, Notes on the Genus *Lichas*, 42; Woodwardian Museum Notes, 122, 145, 256, 337.
Reid, C., Geology of the Country around Southampton, 524; *Offaster pilula*, 527.
Reid, Bennett, & Dixon, Geology of the Country around Ringwood, 525.
Relation of certain Breccias to the Physical Geography of their Age, 141.
Relation of Changes of Level to Interglacial Periods, 59.

SEQ

Relations of the Silurian and Ordovician Rocks of N.W. Ireland to the Great Metamorphic Series, 172.
Remarks on the Atlantis Problem, 455.
Retirement of Dr. Henry Woodward, 1.
Reynolds, S. H., On the Jurassic Strata between Filton and Wootton Bassett, 426.
Reynolds & Gardner, Fossiliferous Silurian Beds, etc., at Clogher Head, 139.
Rhodes, J., Phosphatic Nodules in the Upper Carboniferous Limestone Series, 39.
Richardson, L., Sequence of the Inferior Oolite Deposits of Bredon Hill, 512.
Rickman, T. M., Von Zittel's History of Geology, 333.
Riddle of the Universe, 78.
Ringwood, Geology of the Country around, 525.
River-System of South Wales, Origin of the, 189.
Rivers, Development of, 366, 479, 527.
Rivers of Wales, 428.
Roads: their Construction and Maintenance, 76.
Rock-specimens from the Canadian Rockies, 544.
Roemer, Dr. Ferdinand von, Life of, 412.
Royal Society's Catalogue, 561.
Royal Society of New South Wales, 571.
Rudler, F. W., Retirement of, 528.
Rufford, P. J., Obituary of, 430.
Rugby School Museum, 478.

SAINT-LAWRENCE-Champlain-Appalachian Faults of America, 425.
Salter's Undescribed Trilobites, 122, 145, 256, 337.
Say's Types of Maryland Mollusca in the British Museum, 303.
Scalaria communis in the Raised Beach on the Thatcher Rock, 285.
Scharff, R. F., Remarks on the Atlantis Problem, 455; Exploration of Kesh Caves, Ireland, 505.
Schists of S. Devonshire, Hydrothermal Metamorphism of the, 474.
Scott, D. H., Primitive Type of Structure in *Calamites*, 73.
Scottish Copper-Ores in their Geological Relations, 74.
Sea-Coast, The, 276.
Sedimentary Deposits, Original Form of, 473.
Seeley, H. G., Cretaceous Fossils from the Salt Range, India, 471.
Sequence of the Inferior Oolite Deposits of Bredon Hill, 513.

SEY

Seymour, H. J., Preliminary List of Minerals occurring in Ireland, 500.
Sheppard, T., *Ichthyosaurus thyreospondylus* from the Kimeridge Clay of Speeton, 427.
Sherborn, C. D., Geological Society of London, Lake *v.* Strahan, 384; Geological Survey of England and Wales and the White Chalk, 478.
Silurian Area of North-East Ireland, Fossils from the, 497.
Simonds, F. W., Life of Dr. F. von Roemer, 412.
Sirabé, A nearly complete skeleton of *Hippopotamus Madagascariensis* from, 193.
Sligo, County, Exploration of Kesh Caves, 505.
Smith, J., Marine Shells, 479.
Smithe, Rev. F., Obituary of, 143.
Snowdon, Effects of Lightning near, 142.
Sodalite Syenite from the Ice River Valley, Canadian Rockies, 199.
Sollas, W. J., A Process for the Mineral Analysis of Rocks, 140.
'Sonorous' Sand, 573.
South Africa, Correlation of the Palæozoic Rocks of, 164, 210.
South African Petrography, 356, 574.
South Australia, Record of the Mines of, 418.
Spencer, J. W. W., Geological and Physical Development of Dominica, 80; Geological and Physical Development of Barbados, 82.
Staffordshire, Some Trias Sections in South, 213.
Steart, F. A., Overthrusts and other Disturbances in the Braysdown Colliery, 329.
Stocks, H. B., Origin of certain Concretions in the Lower Coal-measures, 44.
Stone Implements, Value of Mineral Condition in determining the Age of, 97.
Stonehenge and Avebury, A Bibliography of, 275.
Strahan, A., Origin of the River-System of South Wales, 189; Bala Lake and the River-System of North Wales, 384; Development of Rivers, 479.
Stratigraphical Geology, The Student's Handbook of, 279.
Stuart-Menteath, P. W., The Pyrenees at the last Geological Congress, 349.
Sub-Fossil Yew-Wood, 48.
Sub-Oceanic River Valleys, 286.
Suffolk, Some Railway Cuttings in, 129.
Summary of Progress of the Geological Survey for 1901, 525.

WAR

TATE, Professor Ralph, Obituary of, 87.
Tertiary Deposits of Southern Australia, 478.
Thomas, H. H., On the Bunter Pebble-Bed in the West of England, 327.
Thompson, B., Some Trias Sections in South Staffordshire, 213.
Tiddeman, R. H., Retirement of, 144.
Tmaegoceras, Note on the Genus, 127.
Torell, Dr. Otto, Obituary of, 238.
Traquair, R. H., Additional Note on *Drepanaspis Gemündenensis*, Schlüter, 389.
Trias Sections in South Staffordshire, 213.
Trilobite from the *Dictyonema*-shales of the Malvern Hills, 70.
Trilobites, The Ventral Integument of, 154.
Trilobites from the Cambrian of the Canadian Rockies, 502, 530.
Trilobites from the Culm-measures near Barnstaple, 481.
Trogontherium from a Pleistocene Deposit in the Thames Valley, 385.
'Type' Specimens in the Norwich Museum, 166, 220.
Types of Maryland Tertiary Mollusca in the British Museum, 303.

USSHER, W. A. E., Geology of the Country around Southampton, 524; Radiolarian Cherts in the Culm, 576.

VALLEYS at the Head of Hardanger Fjord, Norway, 476.
Valvulina Schwageri, Chapman, sp. nov., 107.
Ventral Integument of Trilobites, 154.
Vindication of Bacon, Huxley, Darwin, and Lyell, 265.
Viscous Fusion of Rock-forming Minerals, 475.
Volcanic Ash which fell on Barbados, 332.
Volcanic Phenomena, Illustrations of, 378.
Von Ihering, on Patagonian Tertiary Mollusca, 562.
Von Koenen, on the North German Lower Cretaceous, 561.
Von Zittel's History of Geology, 333.

WADI-NATRUN, Pliocene Vertebrate Fauna from, 433.
Walford, A. E., On some Gaps in the Lias, 189.
Warren, S. H., Value of Mineral Condition in determining the Relative Age of Stone Implements, 97.

Washington, H. S., Igneous Rocks of Arkansas, 177.
Water Supply of Berkshire from Underground Sources, 138.
Watson, J. A., Dean Buckland and McEnery, 85.
Wedd & Gibson, Geology of the Country around Stoke-upon-Trent, 563.
Weinschenck's History of Graphite, 180.
Westleton Beds, Further Note on the, 27.
Wheeler, W. H., The Sea-Coast, 276.
Whitaker & Blake, Water Supply of Berkshire, 138.
White, H. C. O., Mr. Strahan and some English Rivers, 334.
Wood's Point Dyke, Victoria (Australia), 284, 392.
Woodward, A. S., appointed Keeper of the Geological Department, British Museum, 96; Catalogue of Fossil Fishes, 133; Notes on Footprints from the Keuper of South Staffordshire, 215; Carboniferous Fish Fauna of Victoria, Australia, 471.
Woodward, Henry, Retirement of, 1; Culm Trilobites from Coddon Hill, 481; On Middle Cambrian Fossils of the Canadian Rockies, 502, 530.
Woodward, H. B., Note on the Westleton Beds, 27; Notes on some Railway Cuttings in Suffolk, 129; Bagshot Beds at Combe Pyne, 515.
Woodwardian Museum Notes, 122, 145, 256, 337.
Wright, J., Marine Fauna of the Boulder-clay, 518.

YOSHIWARA, S., On the Bonin Islands, 296.

ZIGZAG Course of the Cheddar Gorge, 67.
Zurcher & Bertrand, On Central American Geology, 419.

STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.

No. 462. New Series.—Decade IV.—Vol. IX.—No. XII. Price 1s. 6d. nett.

THE GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S., &c., WILFRID H. HUDLESTON, F.R.S., &c.

DR. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

LIBRARY OF THE UNIVERSITY OF WISCONSIN MADISON

DECEMBER, 1902.

CONTENTS.

I. ORIGINAL ARTICLES. PAGE

1. On Middle Cambrian Fossils of the Canadian Rockies. By H. WOODWARD, LL.D., F.R.S. (Plate XXII and 7 Woodcuts.) (Continued from p. 505.)..... 529
2. On some Rock-specimens from the Canadian Rockies. By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S. 544
3. The Geology of Barbados. By Prof. J. B. HARRISON, C.M.G., F.G.S., & A. J. JUKES-BROWNE, B.A., F.G.S. 550
4. The Term 'Hemera.' By S. S. BUCKMAN, F.G.S. 554

II. NOTICES OF MEMOIRS, ETC.

1. Manganese in Sedimentary Rocks. By W. Mackie, M.A., M.D. .. 558
2. The so-called 'Fossil' Water. By W. Mackie, M.A., M.D. ... 559
3. Ten short Notices 561

III. REVIEWS. PAGE

1. Geological Survey of England and Wales (Stoke-on-Trent) ... 563
2. Supplement to the Encyclopædia Britannica 567
3. Fossil Vertebrata of North America. By O. P. Hay 569
4. Prehistoric Remains in Harlyn Bay. By R. Ashington Bullen, B.A., F.L.S., F.G.S..... 570

IV. REPORTS AND PROCEEDINGS.

The Royal Society of New South Wales..... 571

V. CORRESPONDENCE.

1. A. R. Hunt, M.A., F.G.S. ... 572
2. H. J Lowe, F.G.S. 573
3. F. P. Mennell, Esq..... 574
4. Professor G. A. J. Cole 574
5. G. W. Lamplugh, F.G.S. 574
6. G. W. Lamplugh, F.G.S. 575
7. W. A. E. Ussher, F.G.S. 576

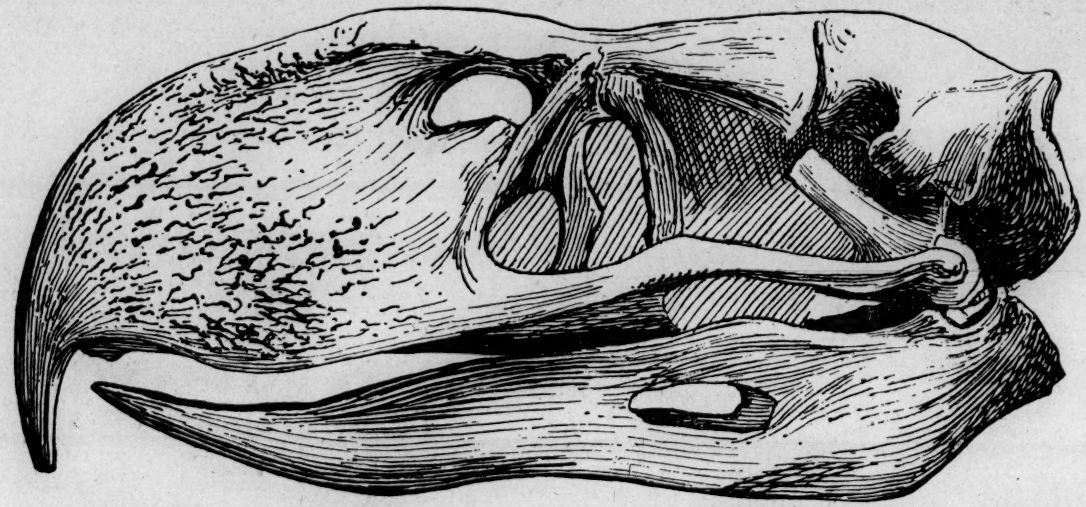
VI. OBITUARY.

William Gunn, F.G.S. 576

With this Number is presented an Extra Sheet, containing Index and Title for Decade IV, Vol. IX, 1902.

LONDON: DULAU & CO., 37, SOHO SQUARE.

☞ **The Volume for 1901 of the GEOLOGICAL MAGAZINE is ready, price 20s. nett. Cloth Cases for Binding may be had, price 1s. 6d. nett.**



Mr. ROBERT F. DAMON, Naturalist, WEYMOUTH, ENGLAND,

Can now supply Copies of the Coloured Life-size Model of the Skull and Mandible of the Gigantic Extinct Bird

PHORORHACOS LONGISSIMUS, Ameghino.

The Mandible has been slightly restored from the actual specimen, and the Skull has been modelled from that of the somewhat smaller species *Ph. inflatus*, figured by F. Ameghino (1895), Buenos Ayres, from the TERTIARY DEPOSITS (MIOCENE ?), SANTA CRUZ, PATAGONIA. Described by Mr. C. W. Andrews in the *Ibis*, January, 1896, pp. 1–12.

(The original specimens are in the Geological Department of the British Museum (Natural History).)

PRICE OF COLOURED CAST, length 24 inches (60 cm.), CAREFULLY PACKED, £5.

DULAU & CO., 37, SOHO SQUARE, LONDON, W.

GEOLOGICAL BOOKS AND PAPERS.

SHRUBSOLE (O. A.). High-level Gravels in Berkshire and Oxfordshire. 1898. 8vo. Map. 1s.

SMITH (J.). The Great Ice Age in the Garnock Valley. 1890. 8vo. Four plates. 1s. 6d.

SOLLAS (W. J.). Map to show the distribution of Eskers in Ireland. 1896. 4to. Coloured plate. 1s. 6d.

SYMONDS (W. S.). The Severn Straits, or notes on Glacial Drifts, etc. Tewkesbury, 1883. 8vo. 1s. 6d.

TODD (J. E.). The Moraines of the Missouri Coteau, etc. Washington, 1896. 8vo. 21 plates. 1s. 6d.

——— The Moraines of South-Eastern South Dakota. 1899. 8vo. 27 plates. 2s.

TODD (J.). Richthofen's Theory of the Loess. 1878. 8vo. 6d.

TRAUTSCHOLD (H.). Gletscher in Russland. 1892. 8vo. 1s.

TRAVERS (W.). Dr. Haast's supposed Pleistocene Glaciation of New Zealand. On the Date of the Glacial Period; by A. DOBSON. The Glacial Period of New Zealand; by T. MACKAY. 1874. 8vo. 2s.

AMERICAN NATURALIST (THE). A Popular Illustrated Magazine of Natural History. Salem, 1868–1902. 8vo. Plates. Complete perfect copy. Vols. i–xix, newly bound in half green morocco, marbled edges; vols xx–xxii, in half-russia. Vols. xxiii–xxxvi in numbers. £30

GEOLOGICAL SOCIETY OF LONDON. Abstracts of Proceedings from November, 1872, to June, 1876. 8vo. Cloth. 3s.

——— QUARTERLY JOURNAL. From the commencement in 1845 to the end of 1896. 8vo. Plates. Vols. i–liii. Half-calf. With Ormerod's Index, first and second editions, and General Index. Vols. i–l. 2 parts. Fine perfect set. £35

——— ——— Another set. Vols. i–li. 47 vols. bound, the others unbound. £30

GEOLOGIST AND GEOLOGICAL MAGAZINE. A complete set, from the commencement in 1858 to the end of 1898. Bound in cloth. £18 18s.

JOURNAL OF NATURAL PHILOSOPHY, CHEMISTRY, AND THE ARTS. NICHOLSON (W.). 1797–1802, five vols.. 4to, half-calf; and 1802-13, 36 vols., 8vo, half-morocco. £7

JOURNAL OF THE ROYAL MICROSCOPICAL SOCIETY. London, 1878–1900. 8vo. Plates. A complete collated set. £20

NATURAL SCIENCE. A monthly review of Scientific Progress. London, 1892–99. Vols. i–xv. 8vo. Illustrated. £4 4s.

NATURE. A Weekly Illustrated Journal of Science. London, 1870–99. Vols. i–lix. Five half-bound, remainder in cloth. Small 4to. £20

——— Vols. i–liv. 38 vols. in cloth, remainder in numbers. £18

NEW YORK STATE CABINET OF NATURAL HISTORY. Complete set of the Reports from the commencement in 1848 to 1879. Albany. 31 parts. 8vo. Cloth and sewed. With numerous plates. Very scarce. £8 8s.

——— Reports. Albany. 8vo. Plates.
20th, 1870, 6s.; 21st, 1871, 2s. 6d.; 23rd, 1873, 2s. 6d.

NEW ZEALAND INSTITUTE. Transactions and Proceedings. Vols. i–xxviii. With Index to vols. i–viii. Wellington, 1869–95. 8vo. Plates. Vols. i-vi bound in half-calf, remainder as published. £28

RAY SOCIETY'S PUBLICATIONS. A complete set from the commencement in 1844 to 1895. 8vo and folio. £45

REVISTA DEL MUSEO DE LA PLATA. La Plata, 1890–93. Vols. i–iv. Royal 8vo. Plates. £2 2s.

ROYAL SOCIETY OF LONDON. Philosophical Transactions from 1665 to 1800 abridged, 1801–96 at large, including extra volume. London. 4to. Plates. Mostly bound in cloth. £120

——— PROCEEDINGS. London, 1832-1902. Vols. i–lxx. 8vo. Plates. (Many separate papers can also be supplied.) £25.

DULAU & CO., 37, SOHO SQUARE, LONDON, W.

GEOLOGICAL BOOKS AND PAPERS.

SCIENCE GOSSIP. A complete set from the commencement in 1866 to August, 1893 (September to December never published), 1894 to 1896. London. Bound. Small 4to. Illustrated. (Odd volumes can be supplied.) £4

SCIENCE PROGRESS. London, 1894–98. 7 vols. 8vo. Perfect collated copy. £3 13s. 6d.

TRANSACTIONS OF THE ROYAL IRISH ACADEMY. Vols. i–xxiii. Dublin, 1787–1856. 23 vols. 4to. A fine perfect copy. Newly bound in half-morocco, gilt top. £25

ANDREAE (A.). Über das elsässische Tertiär und seine Petroleumlager. 1887. 8vo. 1s.

BROWN (C. B.). On the Tertiary Deposits of Brazil. 1878. 8vo. Plate. 9d.

FORIR (H.). Dépôts tertiaires de l'Entre-Sambre-et-Meuse. 1898. 8vo. 1s.

FRAAS (E.). Geologische Aufbau des Steinheimer Beckens. 1900. 8vo. 9d.

HARMER (F. W.). Dépôts tertiaires supérieurs du bassin Anglo-Belge. 1897. 8vo. Map. 1s. 3d.

HEILPRIN (A.). Tertiary Geology of the Southern United States. 1881. 8vo. 6d.

HERSHEY (H.). Peneplains of the Ozark Highland. 1901. 8vo. 1s.

HUTTON (F.). Synopsis of the Younger Formations of New Zealand. 1873. 8vo. 9d.

JOHNSTON (R.). Tertiary and Post-Tertiary Deposits in Bass Straits. 1878. 8vo. Plate. 9d.

KOKEN (E.). Ueber das Tertiär der Alb. 1. 1900. 8vo. 6d.

KOTO (B.). Geology of the dependent Isles of Taiwan. Tokyo, 1899. 4to. Five plates. 2s. 6d.

LOHEST (M.). Dépôts tertiaires de l'Ardenne et du Condroz. 1896. 8vo. 1s.

MANTOVANI (P.). Formazione geologica delle Colle presso Ancona. 1875. 8vo. Plate. 1s.

MARTIN (K.). Brackish-water Deposits of the Melawi, Borneo. 1899. 4to. 9d.

MATTHEW (W. D.). Is the White River Tertiary an Æolian Formation? 1899. 8vo. 9d.

——— Provisional Classification of the Fresh-water Tertiary of the West. New York, 1899. 8vo. 1s. 6d.

REUSS UND MEYER. Die tertiären Süsswassergebilde des nördlichen Böhmen's und ihre fossilen Thierreste. Cassel, 1852. 4to. 12 plates. 6s.

SEGUENZA (G.). Cenni intorno la Serie terziaria di Messina. 1873. 8vo. 1s.

STRAHAN (A.). On Overthrusts of Tertiary Date in Dorset. 1895. 8vo. Two plates. 1s.

VASSEUR (G.). Formations tertiaires supra-Nummulitiques de l'Ariège. 1902. 8vo. Map. 1s.

——— Recherches géologiques sur les Terrains tertiaires de la France occidentale. Paris, 1881. 8vo. Six coloured maps. 6s.

All Communications for this Magazine should be addressed

TO THE EDITOR OF THE GEOLOGICAL MAGAZINE,

129, BEAUFORT STREET, CHELSEA, LONDON, S.W.

Books and Specimens to be addressed to the Editor, care of

MESSRS. DULAU & CO., 37, SOHO SQUARE, LONDON, W.

STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.